

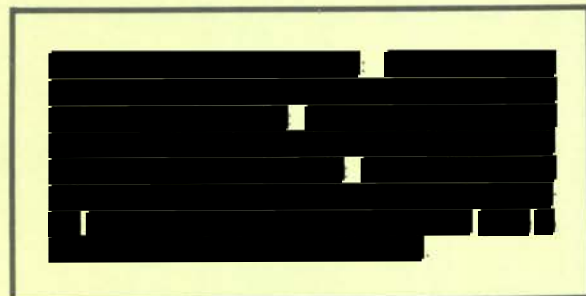
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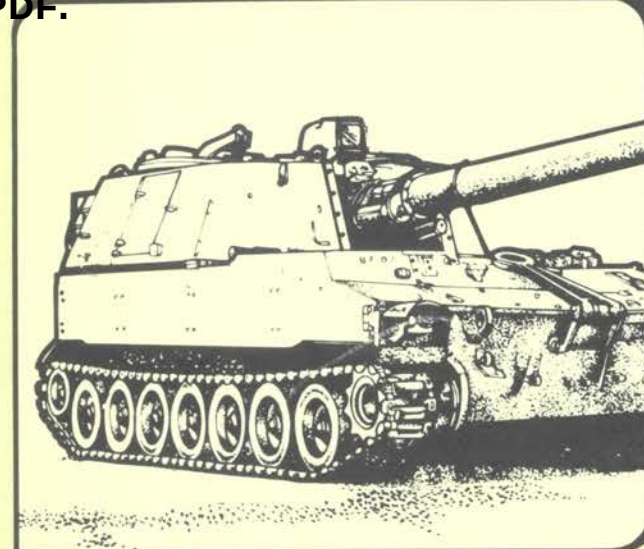
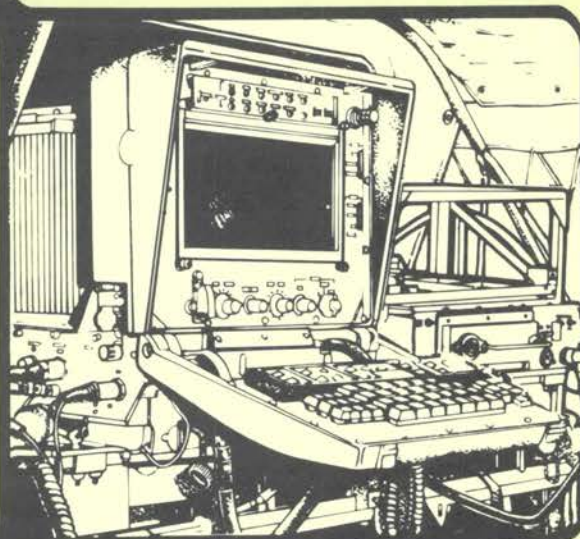


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FIELD ARTILLERY CANNON GUNNERY



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FIELD ARTILLERY CANNON GUNNERY

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Preface

FM 6-40 provides an explanation of equipment and munitions and their associated fire direction procedures for the field artillery (FA) cannon systems. This publication serves as the basis for operational procedures for technical fire direction and as a guide for unit training. It has been developed with the five basic rules of combat applied: *move, shoot, communicate, secure, and sustain*.

The target audience of this publication includes trainers and supervisors of cannon fire direction centers, battalion/brigade operations sections, and others who need an understanding of technical cannon fire direction. Certain chapters are the "how to" references for 13E soldier's manual tasks. Users must be familiar with and use FM 6-20, FM 6-20-1, FM 6-30, FM 6-50, and FM 6-141-1/2.

It is envisioned that this will be the final edition of FM 6-40. Changes to this edition will be published as new equipment, ammunition, or procedures are developed. A training circular (TC 6-1-2) and a job aids have been published for the battery computer system (BCS). The backup computer system (BUCS) program will be fielded in 1985. When this program is completed and a decision on the hardware is made, a BUCS job aids will be published. A new FM containing BCS and BUCS fire direction procedures will be published and fielded in FY 86.

Field artillery doctrine concerning firing unit survivability requires technical procedures that allow the unit to occupy large areas of terrain in the best possible way. Occupation of a position greater than 250 meters by 150 meters requires special corrections to firing data.

a. The battery computer system automatically applies special aiming points and sheafs for all weapons in the unit.

b. The field artillery digital automatic computer (FADAC) or manual fire direction procedures require the application of special corrections to firing data. Two methods may be used.

(1) Mass fires of the platoons (plt) onto the target. This procedure requires plotting the platoon location on the firing charts and computing separate sets of firing data for each platoon (or using FADAC mass fire for the separate platoon centers).

(2) Use special corrections to battery (btry) center data for each platoon. These corrections normally are done by using hasty corrections from tables discussed in chapter 13 and included in appendix A. If time permits, individual piece corrections may also be computed manually (chap 13).

c. When firing data are being computed manually, the unit commander should consider positioning one weapon at the geographical battery center.

This is not a requirement; however, manually computed fires will be more accurate if the adjusting piece is located at the point used as the battery (or platoon) center. In all cases, common sense and the tactical situation dictate the emplacement of weapons and the selection of technical firing data techniques.

The order of technical data computation is BCS, tactical fire direction system (TACFIRE) modification solution, BUCS, manual, and hand-held calculator (HHC). For further discussion, refer to chapter 4.

Included in this publication are guidelines for the interchangeability of ammunition (app B), a listing of fire direction center equipment (app C), and a discussion on employing armor in the role of indirect fire (app D).

Users of this publication are encouraged to submit recommended changes or comments to improve the publication. Comments should be keyed to a specific page, paragraph, or line of text in which the change is recommended. Reasons should be included for each comment to ensure understanding and complete evaluation. Changes and comments should be prepared on DA Form 2028 (Recommended Changes to Publications and Blank Forms) and forwarded directly to:

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US Army Field Artillery School
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The provisions of this publication are the subject of standardization agreement (STANAG)/quadripartite standardization agreement (QSTAG) 4119/220 and QSTAG 224. See appendix E.

This publication contains standardized procedures relevant to field artillery cannon gunnery. Those procedures are denoted in the text by an asterisk (*). See appendix F.

When used in this publication, "he," "him," "his," and "men" represent both the masculine and feminine genders unless otherwise stated.

HOW TO USE THIS PUBLICATION

This publication is a reference and training document for technical cannon fire direction. It may be used by all persons needing this information. Information and tasks required by persons performing specific duties are addressed in various chapters. The entire publication defines and lists all technical fire direction tasks and provides information needed by the gunnery team to successfully perform technical fire direction.

Below is a guide showing the chapters that will be of use to personnel in specific jobs. These chapters should be used as primary references before other parts of this or other publications are consulted.

FA UNIT COMMANDERS, FIRE DIRECTION OFFICERS, AND CHIEF COMPUTERS SHOULD READ ALL CHAPTERS

FA BRIGADE/BATTALION S3s SHOULD READ CHAPTERS 1, 2, 3, 4, 5, 6, 7, 8, 11, 13, AND 14

COMPUTER/BCS OPERATORS SHOULD READ CHAPTERS 1, 10, 11, AND 13

CHART OPERATORS SHOULD READ CHAPTERS 1, 8, 11, AND 13

RADIOTELEPHONE OPERATORS SHOULD READ CHAPTERS 1, 8, 9, AND 11

OBSERVERS SHOULD READ CHAPTERS 1, 2, AND 4



CHAPTER 1

GUNNERY TEAM

The field artillery gunnery team consists of the observer, the fire direction center (FDC), and the firing battery, all linked by an adequate communications system.

1-1. OBSERVER

a. The observer/target acquisition assets serve as the eyes of all indirect fire systems. An observer detects and locates suitable indirect fire targets (tgt) within his zone of observation. When a target is to be attacked, the observer, when necessary, transmits a request for fire and adjusts the fires onto the target. An observer provides surveillance data of his own fires and any other fires in his zone of observation.

b. Maneuver personnel may function as observers. When an individual detects and locates a suitable target, he transmits a request for fire, adjusts the fires onto the target when necessary, and provides surveillance data of his fires and any other fires in his zone of observation.

c. Target acquisition devices also function as observers and provide accurate and timely detection, identification, and location of ground targets to collect combat/target information, to orient/cue intelligence sources, and to permit immediate attack on specific areas. Once combat begins, initial artillery targets will be located by the use of the following field artillery target acquisition assets:

- (1) Moving-target-locating radar sections.
- (2) Weapon-locating radar sections.

- (3) Sound ranging platoons.
- (4) Remotely piloted vehicles (RPV).

Note. See FM 6-121 and FM 6-122 for a discussion of these assets.

1-2. FIRE DIRECTION CENTER

The FDC is the control center for the gunnery team. The FDC personnel receive fire requests from the observer and process that information by using tactical and technical fire direction procedures. They plot the target on the firing chart or a map, determine firing data, and issue fire commands to the firing battery weapons designated to fire the mission. The battery FDC normally conducts technical fire direction by using the BCS or a backup means while the battalion (bn) FDC conducts tactical fire direction with TACFIRE. Technical fire direction is the process of converting weapon and ammunition characteristics (muzzle velocity, propellant temperature, and projectile [proj] weight), weapon (wpn) and target location, and meteorological (met) information into firing data. The results of this process are charge,

fuze (fz) setting, deflection (df), and quadrant elevation (QE). Tactical fire direction is the process of analyzing fire requests and determining appropriate fire method, ammunition expenditure, unit(s) to fire, and time of attack.

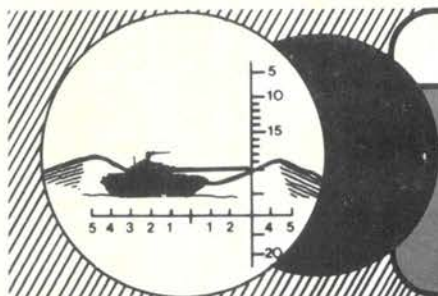
1-3. FIRING BATTERY

The firing battery consists of the howitzer sections and the ammunition section. Organization and employment con-

siderations are discussed in FM 6-50 and FM 6-20-1.

1-4. COMMUNICATIONS LINKS

The gunnery team communications links consist of voice and digital communications. All members of the gunnery team must aggressively ensure adequate communications are established and maintained at all times.



CHAPTER 2

GUNNERY PROBLEM

Field artillery weapons normally are emplaced in defilade to conceal them from the enemy. Usually, this emplacement precludes direct fire on the target. Consequently, indirect fire must be used to attack targets. The gunnery problem is indirect fire. The solution to this problem requires weapon and ammunition settings which, when applied to the piece and ammunition, will cause the projectile to burst on the target or at a proper height above the target.

2-1. GUNNERY PROBLEM SOLUTION

a. The steps in solving the gunnery problem are as follows:

- (1) Know the location of the gun and determine the location of the target.
- (2) Determine chart (map) data (direction, range [rg], and angle T).
- (3) Compensate for nonstandard conditions that would have an effect on firing data.
- (4) Convert chart data to firing data (charge [chg], fuze setting, deflection, and quadrant elevation).
- (5) Apply the firing data to the gun and ammunition.

b. The solution to the problem provides weapon and ammunition settings that cause the projectile to burst on the target or at a predetermined height above the target.

2-2. REQUIREMENTS FOR ACCURATE PREDICTED FIRE

In solving the gunnery problem, requirements for timely and accurately delivered cannon fire support must be met. When maintaining the demanding level of cannon fires, adjustment cannot be made in every situation. The goal, instead, is to achieve accurate predicted fires to produce first-round fire-for-effect (FFE) missions. Such nonadjusted firing has five requirements that must be met to achieve this goal (fig 2-1). These requirements are target location and size, battery location, ammunition and weapon information, met information, and computational procedures. If these requirements cannot be met completely, degraded FFE missions may result and may have to be replaced with time-consuming adjust fire missions that would reduce the effectiveness of cannon fire support.

a. Target Location and Size. To establish the range from the gun to the target, the accurate and timely detection, identification, and location of ground targets and their size and disposition on the ground must be determined so that accurate firing data can be computed. To determine the appropriate time and type of attack, the target size (radius or other dimensions) and the direction and speed of movement must also be considered. Target location is determined by the use of the assets mentioned in paragraph 1-1.

b. Battery Location. Accurate range and direction from the firing battery to the

target also require the weapons to be located accurately, and this location must be known to the fire direction center. The position and azimuth determining system (PADS) can provide accurate survey information on the battery location. Survey techniques available to the firing battery can also help in determining the location of each weapon. The BCS can identify the grid location of each piece from the aiming circle and can compute the geographical battery center grid. The BCS uses each weapon location individually to compute individual firing data. The term "battery center" indicates the geographical center of the weapons and does not necessarily correspond to any weapon location. No longer is there a base piece. For an adjust fire mission, the BCS automatically designates a different weapon for each mission based on an algorithm in the machine. The FDC, if required, may also manually designate an adjusting piece to the battery computer system.

c. Ammunition and Weapon Information. In the battery computer system, accurate firing data are based on the actual performance of each weapon. The actual

performance is determined by the weapon's muzzle velocities. The firing battery can measure actual muzzle velocity by using the M90 velocimeter (chap 11) and correct it to standard for each weapon, type of propellant, and type of projectile. There is no longer a requirement to conduct a formal calibration, because calibration is conducted continuously by using the M90. Firing tables and technical gunnery procedures allow the unit to account for specific ammunition information (weight, fuze type, rocket motor temperature, or timer temperature); thus, accurate firing data are given.

d. Meteorological Information. The effects of weather on the projectile in flight must be considered. Use of current meteorological information (chap 10) in the computers and in manual computation allows the firing data to compensate for current weather conditions.

e. Computational Procedures. The computation of firing data must be accurate. Procedures programed in the ballistic computers and the manual techniques designed for firing data computation yield accurate firing data.

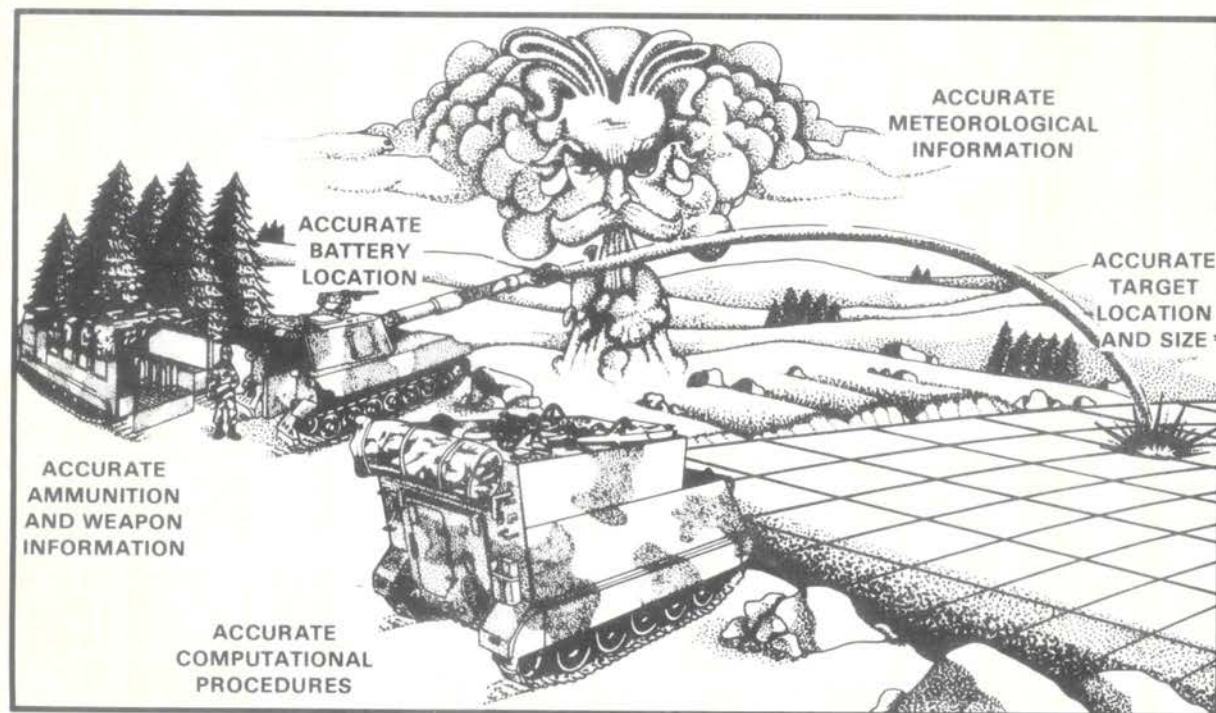


Figure 2-1. Five requirements for accurate predicted fire.



CHAPTER 3

BALLISTICS

Ballistics deals with the motion of projectiles and the conditions that affect that motion. An understanding of ballistics is important because it is upon the fundamentals of ballistics that fire direction procedures are built. It is also important to understand the factors affecting round-to-round variations, particularly in muzzle velocity, so that they can be minimized and the goal of accurate predicted fires can be achieved.

Section I INTERIOR BALLISTICS

3-1. DESCRIPTION

Interior ballistics deals with the factors affecting the motion of the projectile within the tube. Interior ballistics determines the developed muzzle velocity of a round when it leaves the tube.

a. Propellant. Artillery propellant is a low-order explosive that burns at a rate less than 1,300 feet per second. A low-order explosive burns rather than explodes. It burns rapidly and releases gases as opposed to exploding and causing an instantaneous release of energy. The melting point for a low-order explosive is lower than the temperature required to cause it to chemically react. Therefore, it requires a primer for ignition.

b. Cannon Tube. Several parts of the cannon tube affect interior ballistics (fig 3-1).

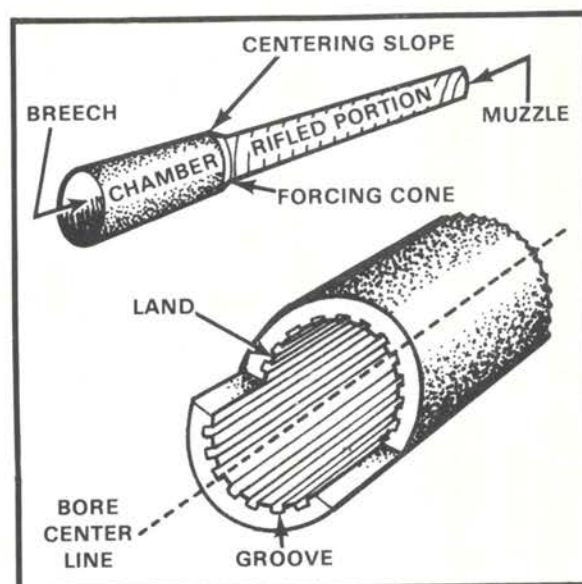


Figure 3-1. The cannon tube.

(1) The rifled portion of the tube imparts spin to the projectile to cause stability in flight. The groove is the depression in the rifling. The land is the raised portion. These parts engrave the rotating band.

(2) The caliber of a tube is the inside diameter of the tube as measured between opposing lands.

(3) Caliber length is the length of the tube in terms of its caliber. Caliber length equals tube length divided by diameter. Weapons can be classified by caliber. Technically, mortars have 10 to 20 caliber lengths, howitzers have 20 to 30 caliber lengths, and guns have more than 30 caliber lengths. All US artillery has a uniform right-hand twist in rifling except the M102 105-mm howitzer, which has an increasing

right-hand twist. This exception was required by the velocity and accuracy requirements for the obsolete 105-mm charge 8 propellant.

(4) The forcing cone is the rear portion of the main bore formed by the tapered lands. It allows the rotating band to be engaged gradually by the rifling.

c. Projectile. The projectile body has several areas that affect ballistics (fig 3-2). Three of these areas affect interior ballistics.

(1) **Bourrelet.** The bourrelet is the area of maximum diameter of the projectile, slightly less than the diameter of the bore. It allows the projectile to ride snugly along the lands of the tube.

(2) **Rotating band.** The rotating band is a band of soft metal (copper alloy)

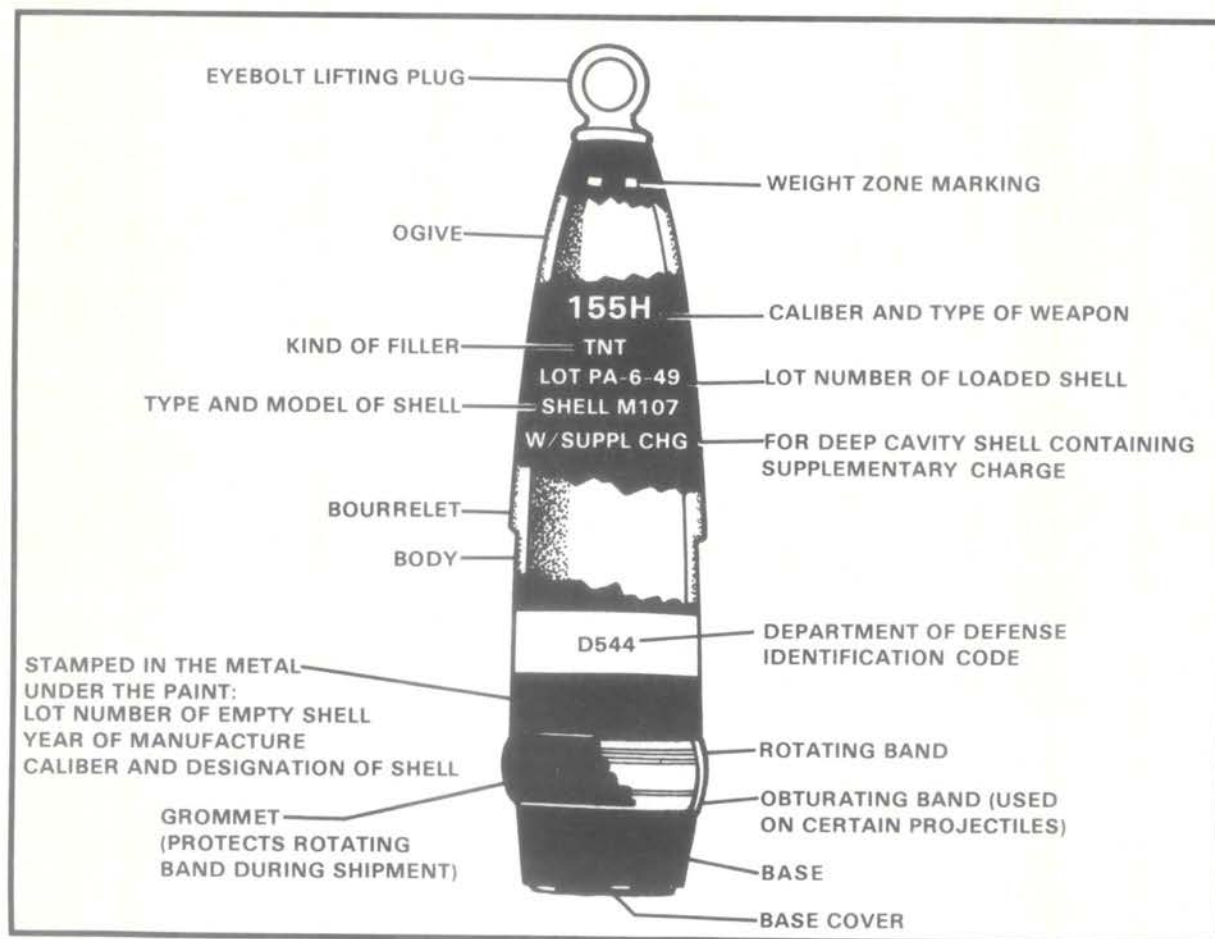


Figure 3-2. The projectile.

that is securely seated around the body of the projectile. It provides forward obturation (the seal required to develop pressure inside the tube). The band prevents the escape of gas pressure from around the projectile. When the weapon is fired, the rotating band contacts the lands and grooves and is impressed between them. As the projectile travels the length of the cannon tube, spin is imparted as it twists over the lands and grooves. The rifling for the entire length of the tube must be smooth and free of burs and scars. This permits uniform seating of the projectile and gives a more uniform muzzle velocity.

(3) **Obturing band.** The obturating band is a nylon band that is on some projectiles. It provides forward obturation and prevents the escape of gas pressure from around the projectile.

d. Actions Within the Cannon Tube.

(1) The projectile is rammed in the cannon tube and rests on the bourrelet. The rotating band contacts the lands and grooves at the forcing cone.

(2) Propellant is inserted into the chamber.

(3) The propellant is ignited by the primer. Propellant burns rapidly and releases large quantities of gas. Gases exert pressure in all directions. Lateral forces are contained by the walls of the chamber and the tube. Longitudinal forces cause the projectile to move—

(a) *Forward.* The projectile moves toward the muzzle. This motion causes the rotating band and obturating band (if present) to be engraved by the rifling of the tube.

(b) *Rotationally.* The engraved rotating band follows the twist of the rifling and imparts a rotational motion to the projectile.

(4) Only about one third of the pressure developed actually works to push the projectile. The remaining two thirds is absorbed by the recoiling parts or is lost because of heat and metal expansion.

(5) The noise and shock of firing are caused by the jet action of the round when it

encounters the atmosphere as it departs the muzzle of the weapon.

3-2. FACTORS AFFECTING MUZZLE VELOCITY

Applicable firing tables give the standard muzzle velocity for each charge. These standard values are based on an assumed standard weapon. In gunnery techniques, nonstandard velocity is expressed as variation (plus or minus so many meters per second [m/s]) from an accepted standard. Actual measurements of the muzzle velocities of a series of rounds corrected for nonstandard conditions show the performance of a certain weapon/ammunition/charge combination and are important in meeting the five requirements of accurate predicted fire. Application of corrections to compensate for nonstandard muzzle velocity is one of the most important elements in the preparation of accurate firing data. The following discussion of factors that cause nonstandard conditions treats each factor separately, assuming there is no influence from related factors.

a. Velocity Trends. Not all rounds (rd) of a series fired from the same weapon and using the same ammunition lot will develop the same muzzle velocity. Under most conditions, the first few rounds follow a somewhat regular pattern rather than the random pattern associated with normal dispersion. This phenomenon is called velocity trends, and the magnitude varies with the cannon, charge, and tube condition at the time each round is fired. Generally, the magnitude of velocity trends can be minimized when firing is started with a tube that is clean and completely free of oil.

b. Ammunition Lots. Each lot of projectiles and propellants has its own mean performance level when related to a common weapon. Each lot must be kept separate from the others. (Fuzes are not separated by lots.)

c. Tolerances in New Weapons. All new cannons will not necessarily develop the same muzzle velocity. In a new tube, the predominant factors affecting MV are variations in the powder chamber and the interior dimensions of the bore.

d. Tube Wear. Continued firing of a cannon wears away portions of the bore by the actions of hot gases and chemicals and movement of the projectile. These erosive actions are more pronounced when higher charges are fired. The greater the tube wear, the more the muzzle velocity decreases. Normal wear can be minimized by careful selection of the charge and by proper cleaning of both the tube and the ammunition.

e. Nonuniform Ramming. Hard, uniform ramming is required for all rounds. Weak, nonuniform ramming causes a combined effect of escaping gases and a smaller propellant chamber. These factors produce an increase in the dispersion pattern.

f. Rotating Bands. Rotating bands allow uniform pressure buildup and provide a minimum dragging effect on the projectile once motion has started. Dirt or burs on the rotating bands cause improper seating. This increases tube wear and contributes to velocity dispersion. If excessively worn, the lands may not sufficiently engage the rotating bands to impart the proper spin to the projectile. Insufficient spin reduces projectile stability in flight and can result in dangerously erratic round performance. When erratic rounds occur or excessive tube wear is noted, ordnance teams should be requested to determine the serviceability of each tube.

g. Propellant and Projectile Temperatures. Positive action must be taken to maintain uniform projectile and propellant temperatures. Failure to take this action results in erratic firing. The effect of an extreme change in projectile or propellant temperature can invalidate even the most recent registration corrections.

h. Moisture Content of Propellant. Changes in the moisture content of propellant are caused by improper protection from the elements. These changes will affect muzzle velocity.

i. Position of Propellant in the Chamber. In fixed and semifixed ammunition, the propellant has a relatively fixed position with respect to the chamber. In separate-loading ammunition, however, the position of the propellant depends on how the cannoneer inserts the charge. To ensure

proper ignition of the propellant, he must insert the charge so that the base of the propellant bag is flush against the obturator spindle when the breech is closed.

j. Weight of Projectile. A heavier-than-standard projectile causes a decrease in velocity. A lighter-than-standard projectile causes an increase in velocity.

k. Coppering. Coppering is the deposit of a thin film of copper on the bore lands. It occurs in the tube when the velocity is high enough to develop sufficient friction to remove the outer surface of the rotating band. The amount of copper deposited varies with velocity. Excessive coppering causes erratic velocity performance by varying the resistance of the bore to projectile movement. Coppering may be reduced by firing lower charges and removed by cleaning the bore.

l. Propellant Residue. Residue from burned propellant and certain chemical agents mixed with the expanding gases are deposited on the bore surface. Proper care and cleaning will alleviate pitting and other damage to the tube.

m. Tube Conditioning. The temperature of the tube has a direct bearing on the developed muzzle velocity. A cold tube offers a different resistance to projectile movement and is less susceptible to coppering, even at high velocities.

n. Tube Memory. Tube memory is the phenomenon that occurs when the tube fires at a muzzle velocity similar to that of the last charge fired, even if the charge is different. For example, if the charge fired was 5 green bag (GB) and the next charge to be fired is 3 green bag, the tube will fire at a slightly higher muzzle velocity than normal for charge 3, because it "remembers" firing the charge 5.

3-3. MUZZLE VELOCITY MEASUREMENT

Various methods are used to determine the developed muzzle velocity of a projectile. Use of the M90 velocimeter is the preferred method. It gives a real-time muzzle velocity that can be used to better realize the artillery goal of accurate predicted fires.

Section II

EXTERIOR BALLISTICS

3-4. DESCRIPTION

Exterior ballistics deals with the factors that affect the motion of a projectile outside the tube.

3-5. TRAJECTORY ELEMENTS

The trajectory is the path traced by the center of gravity of the projectile from the origin to the level point. The elements of a trajectory are classified into three groups: intrinsic, initial, and terminal.

a. Intrinsic Elements. Elements that are characteristic of a trajectory, by definition, are intrinsic elements.

(1) **Origin**—the location of the center of gravity of the projectile when it leaves the tube. It also denotes the center of the muzzle when the piece has been laid.

(2) **Ascending branch**—that portion of the trajectory that is traced by the center of gravity while the projectile is rising from the origin.

(3) **Descending branch**—that portion of the trajectory that is traced by the center of gravity while the projectile is falling.

(4) **Summit**—the highest point of the trajectory.

(5) **Maximum ordinate**—the difference in altitude (alt) between the origin and the summit.

(6) **Level point**—the point on the descending branch that is the same altitude as the origin.

(7) **Base of trajectory**—the straight line from the origin to the level point.

b. Initial Elements. Elements that are characteristic at the origin of the trajectory are initial elements (fig 3-3).

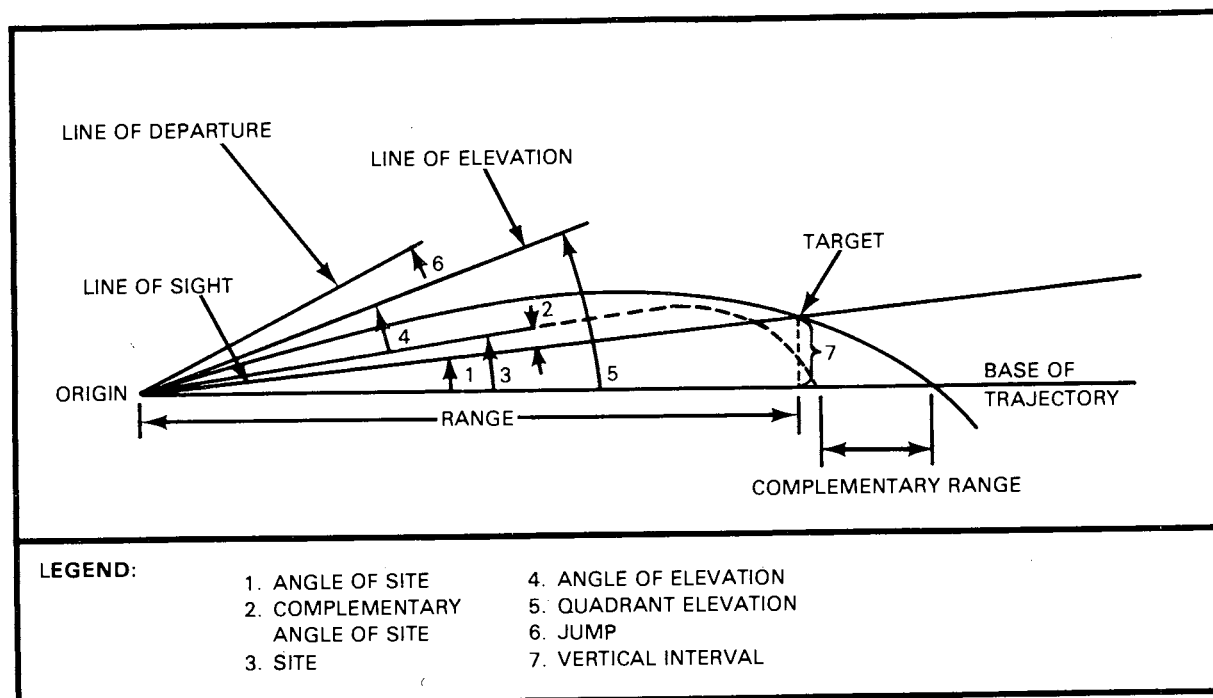


Figure 3-3. Initial elements of the trajectory.

(1) **Line of elevation**—the axis of the tube extended when the piece is laid.

(2) **Line of departure**—a line tangent to the trajectory at the instant the projectile leaves the tube.

(3) **Jump**—the displacement of the line of departure from the line of elevation that exists at the instant the projectile leaves the tube.

(4) **Angle of site**—the smaller angle in the vertical plane from the base of the trajectory to the straight line joining the origin and the target. The angle of site compensates for the vertical interval.

(5) **Complementary angle of site**—an angle that is algebraically added to the angle of site to compensate for the nonrigidity of the trajectory.

(6) **Site**—the algebraic sum of the angle of site plus the complementary angle of site (comp site). Site is computed to compensate in situations where the target is not at the same altitude as the battery.

(7) **Complementary range**—the number of meters range correction equivalent to the number of mils complementary angle of site.

(8) **Line of site**—the straight line from the origin to a point, usually the target.

(9) **Angle of elevation**—the interior angle at the origin in a vertical plane from the line of site to the line of elevation.

(10) **Quadrant elevation**—the interior angle at the origin in a vertical plane from the base of the trajectory to the line of elevation. It is the algebraic sum of site plus the angle of elevation.

c. Terminal Elements. Elements that are characteristic at the point of impact are terminal elements (fig 3-4).

(1) **Point of impact**—the point at which the projectile strikes the target area.

(2) **Angle of fall**—the vertical angle at the level point between the line of fall and the base of the trajectory.

(3) **Line of fall**—the line tangent to the trajectory at the level point.

(4) **Line of impact**—a line tangent to the trajectory at the point of impact.

(5) **Angle of impact**—the acute angle at the point of impact between the line of impact and a plane tangent to the surface at the point of impact.

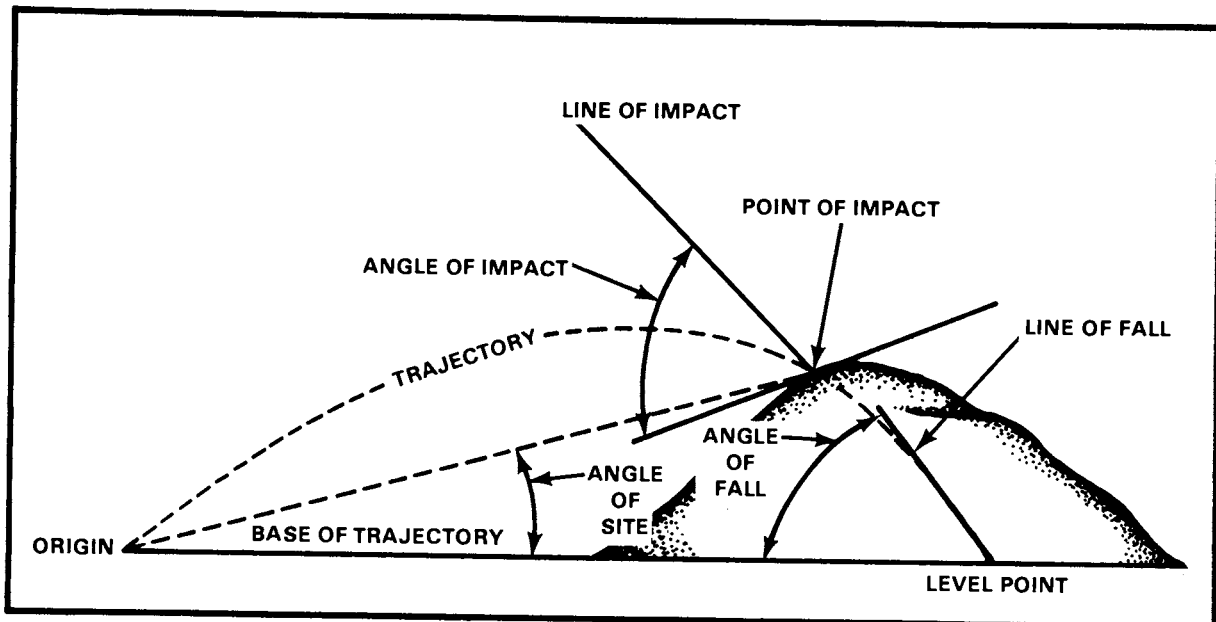


Figure 3-4. Terminal elements of the trajectory.

3-6. ROUND-TO-ROUND VARIATIONS

a. When several rounds are fired from a piece under conditions as nearly identical as possible, the points of impact of the projectiles will be scattered both in range and in direction. This scattering is called dispersion. The area over the points of impact is called the dispersion zone.

b. Dispersion is the result of errors. There are three types of errors.

(1) **Inherent errors**—built-in errors or inaccuracies in the weapon or ammunition (for example, play in the recoil system of a howitzer). Inherent errors cannot be corrected for and are the primary cause of dispersion.

(2) **Human errors**—mistakes made by any member of the gunnery team (for example, inaccurate directions sent by the forward observer [FO], improper computation of data by the FDC, or improper laying of the howitzer by the gunners). Human errors can be corrected by training.

(3) **Constant errors**—errors that are known of and are constant throughout the mission. Constant errors (for example, drift, VI, rotation of the earth) can be corrected by use of the tabular firing table.

c. The center of the dispersion pattern is called the mean point of impact (MPI). The MPI of a small number of rounds will differ slightly from that of a larger number of rounds, since a smaller number of rounds cannot be expected to give a representative sample of the dispersion.

3-7. DISPERSION RECTANGLES

a. If a rectangle is constructed around the dispersion zone (excluding any erratic rounds), it is called the 100-percent rectangle (fig 3-5). If this rectangle is divided into eight equal parts by lines drawn perpendicular to the line of fire, the percentage of points of impact to be expected in each part is indicated in figure 3-6. This is called a range dispersion

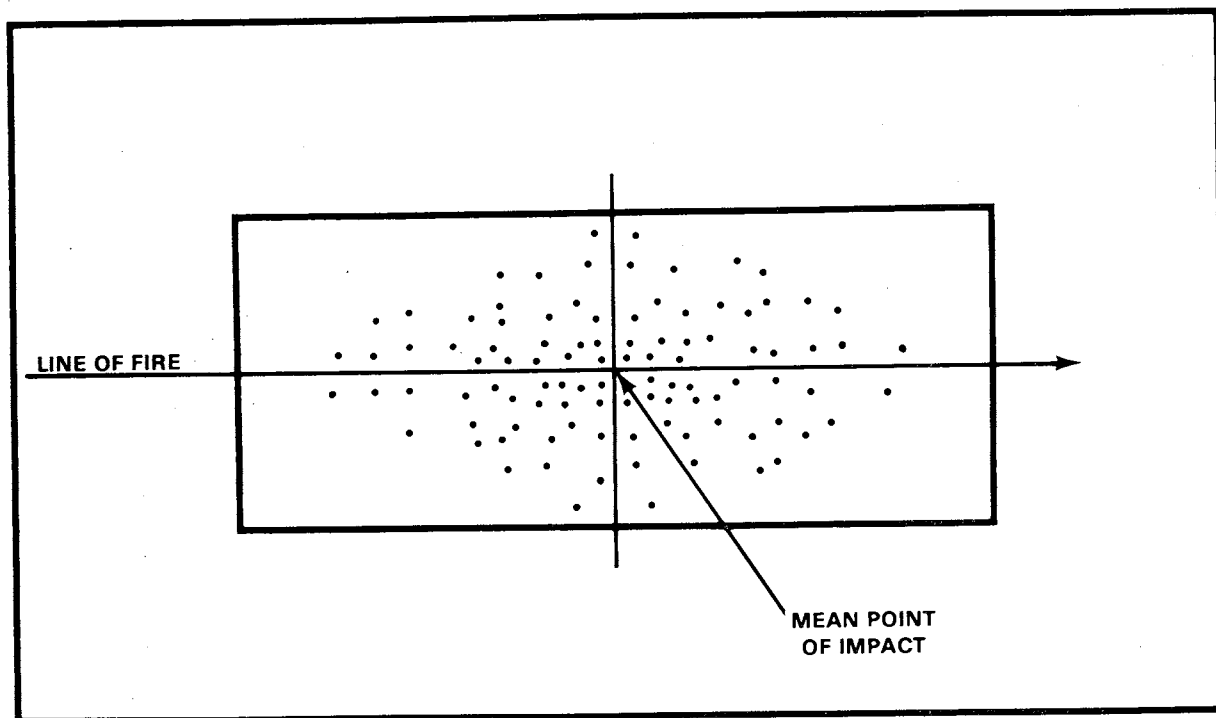


Figure 3-5. The 100-percent rectangle.

rectangle. Likewise, if this rectangle is divided similarly by lines parallel to the line of fire, the percentages will be as indicated in figure 3-7. This is called a deflection dispersion rectangle. Each division of these dispersion rectangles is called 1 probable error. Probable error is defined as the error that is exceeded as many times as not when considering all rounds either over or short or left or right of the mean point of impact.

b. If the range and deflection dispersion rectangles are superimposed, the result is the assemblage of small rectangles shown in figure 3-8. This result is called the dispersion rectangle. The percentage of points of impact in any particular small rectangle is the product of the percentages in two strips, range and deflection, whose intersections form the small rectangle.

3-8. RANGE PROBABLE ERROR

a. In figure 3-6, the line AB through the center of impact is perpendicular to the line of

fire. There are as many points of impact in the area between AB and CD as there are beyond CD; that is, 25 percent of the points of impact are in the area AB-CD and 25 percent are beyond CD. The depth of the area (AC) is called 1 range probable error (PER). The range probable error for a given charge is different at different ranges. The approximate value of the range probable error is given in the firing tables. This value can be taken as an index of the accuracy of the weapon. Firing table values for range probable errors are representative of carefully selected ammunition. The actual probable errors of an ammunition lot can vary from the table values. Probable error is the value which, when added to or subtracted from the expected range, will produce an interval along the line of fire that should contain 50 percent of the rounds fired. Variations in muzzle velocity, angle of departure, and total drag during flight affect this value.

b. From studying figure 3-6, you will determine that 50 percent of the rounds will fall within 1 range probable error, approximately 82 percent will fall within 2

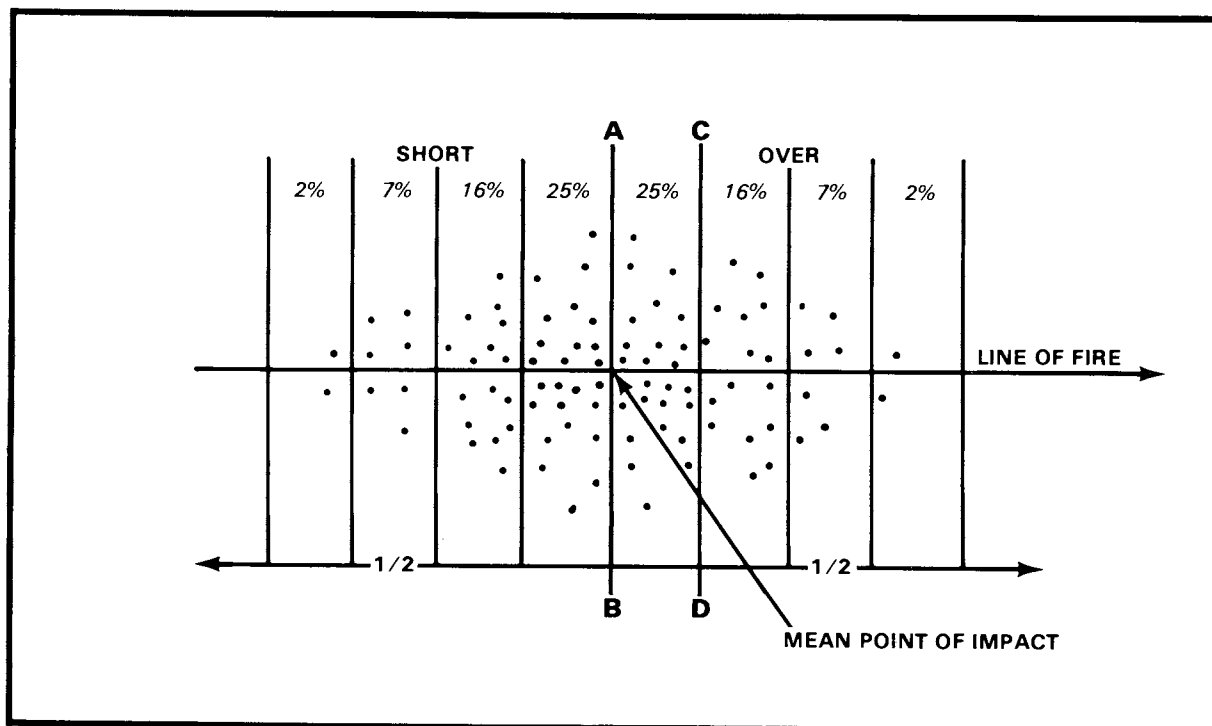


Figure 3-6. Range dispersion rectangle.

probable errors, and 96 percent will fall within 3 probable errors of the mean point of impact. For practical purposes, it is assumed that all rounds will fall within 4 probable errors of the mean point of impact. Actually, a small percentage of the rounds (about 7 in 1,000) will fall farther than 4 probable errors away from the mean point of impact. This probable distribution of rounds (including the fifth probable error) is given more precisely in the probability tables in the firing tables.

3-9. DEFLECTION PROBABLE ERROR

In the deflection dispersion rectangle (fig 3-7), the points of impact to the right and left of the long axis of the rectangle follow principles of distribution similar to those in paragraph 3-7. For practical purposes, the deflection probable error (PE_D) is taken as one eighth of the width of the dispersion rectangle. This value is listed in the tabular firing tables (TFT).

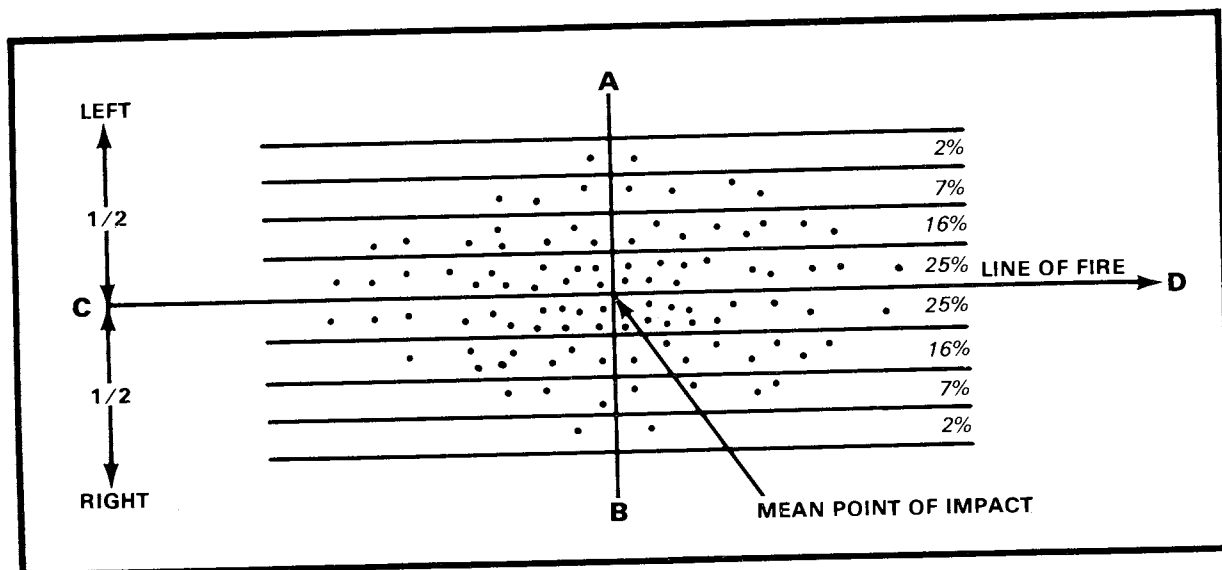


Figure 3-7. Deflection dispersion rectangle.

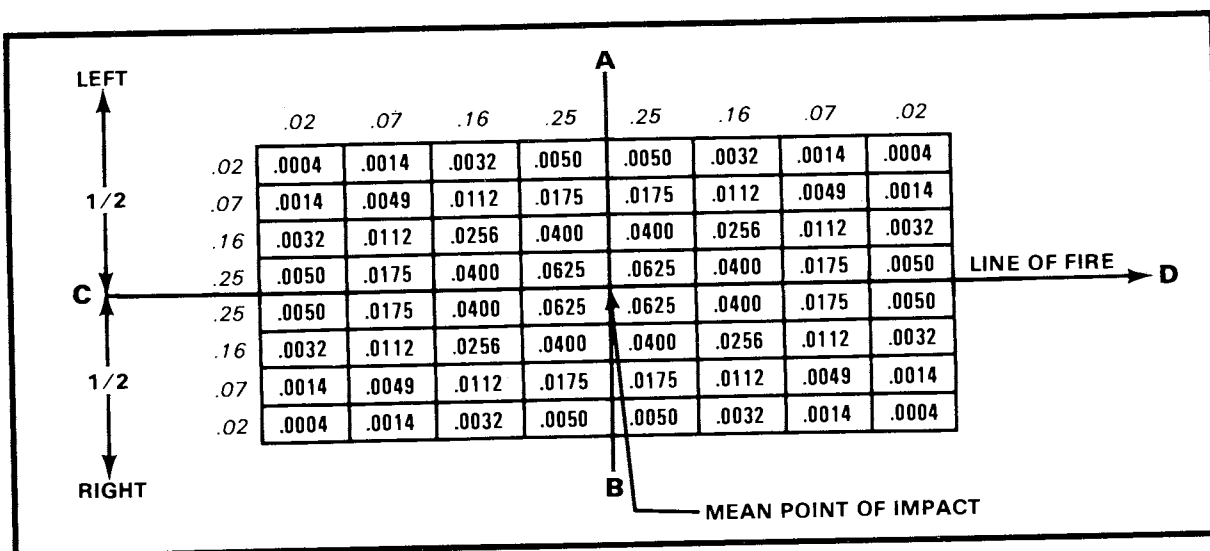


Figure 3-8. Dispersion rectangle.



CHAPTER 4

FIRE DIRECTION CENTER OPERATIONS

Different units may have different types and amounts of FDC equipment.

a. The battery FDC may be configured with one of the following three mixes of equipment:

- (1) BCS/manual.
- (2) FADAC/manual.
- (3) Manual only.

b. The battalion will have TACFIRE or will be a FADAC/manual fire direction center.

c. Duties and responsibilities of assigned personnel will vary depending on the type and the amount of equipment available in the fire direction center.

4-1. BCS/MANUAL FDC

a. *Duties of Personnel.* The highest level of technical fire direction is found in a TACFIRE-controlled/BCS-equipped battery FDC (fig 4-1). By tables of organization and equipment (TOE), this FDC is authorized eight people to fill four positions in two shifts to facilitate 24-hour operations (TOE 6-365J). Methods of training FDC personnel are in appendix G.

(1) **One fire direction officer (LT)**—is responsible for all FDC operations. The fire direction officer (FDO) actively supervises, decides how to attack the target (app H), ensures the required level of training is attained, and ensures a check of all known and firing data.

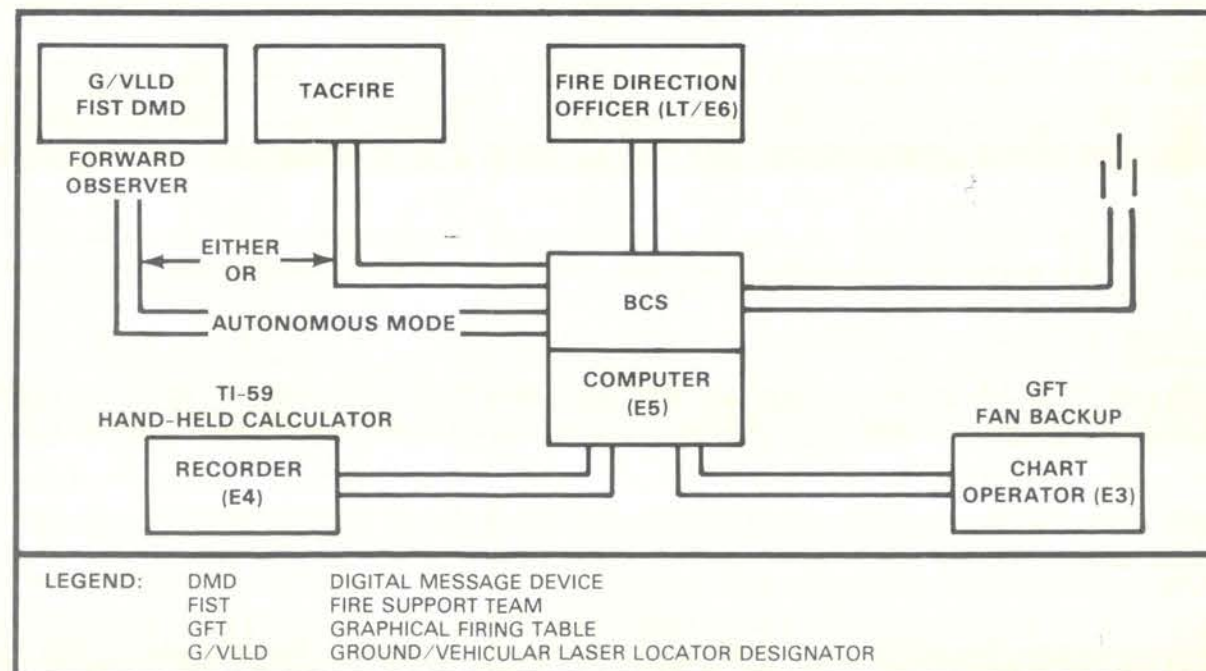


Figure 4-1. BCS-equipped fire direction center.

(2) **One chief fire direction specialist (E6)**—is the technical expert in the fire direction center. He ensures smooth operation of the FDC in 24-hour operations. He acts as a shift supervisor in the absence of the fire direction officer.

(3) **Two computer operators (E5)**—operate the battery computer unit (BCU) and send fire commands to the guns.

(4) **Two recorders (E4)**—maintain records of firing data. As a minimum, the recorders should maintain the firing data of

the piece nearest the battery center and the data required for backup with the hand-held calculator.

(5) **Two chart operators (E3)**—are the horizontal control operator (HCO) and the vertical control operator (VCO). They maintain a firing chart, follow each mission, and check the BCS grid coordinates with chart and situation map coordinates. These double checks ensure that proper data are being used in the BCS solution. They also use the BUCS/graphical firing table (GFT) fan to

provide an additional check of BCS firing data for the adjusting weapon during the adjusting and fire-for-effect portions of the mission.

b. Radio Communications. See figure 4-2 for a diagram of the radio communications used in a direct support (DS) battalion equipped with TACFIRE and the battery computer system.

c. System Degradation. With the introduction of new technical equipment,

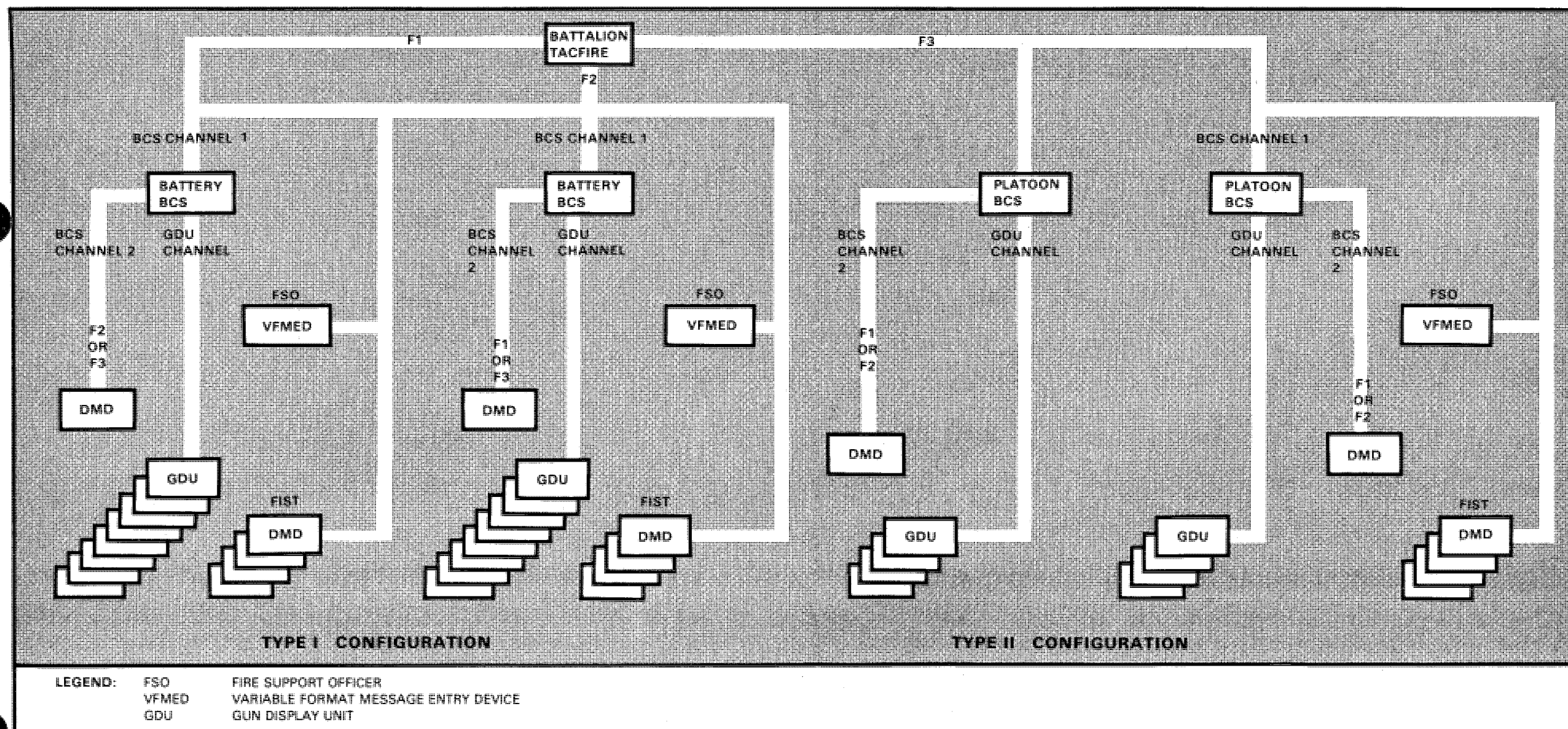


Figure 4-2. Direct support battalion TACFIRE/BCS communications network.

certain situations can cause technical fire direction system degradation. Acceptable gunnery solutions are available, but they necessitate additional actions by certain personnel (table 4-1) and restructuring of communications nets (fig 4-3).

4-2. FADAC/MANUAL FDC

a. Duties of Personnel. The FDO is responsible for the operation of the FDC. Duties include producing accurate and timely firing data. The FDO analyzes the calls for fire and instructs the FDC on how to attack

the target. He is also responsible for checking and entering known data into FADAC/BCS/BUCS/HHC and on the graphical equipment. He and the chief fire direction specialist (E6) actively supervise the rest of the personnel as they perform their duties. The chief fire direction specialist is the primary technical advisor to the FDO, who trains the section. The senior fire direction specialist (E5) operates the FADAC and issues fire commands to the guns. The other personnel serve as radiotelephone operator (RATELO), recorder, and chart operator, as directed. The FADAC/manual FDC is shown in figure 4-4.

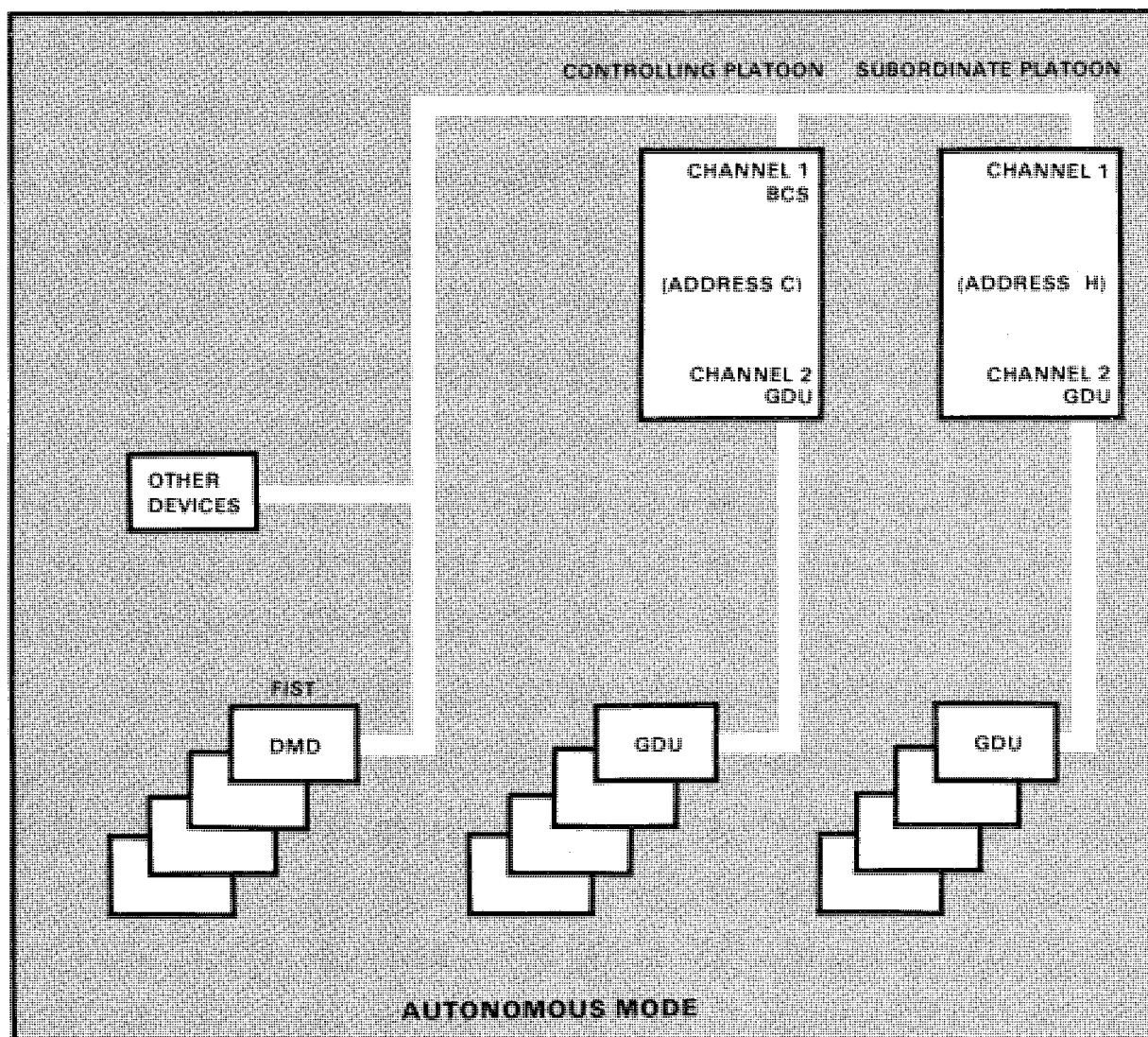


Figure 4-3. J-series battery fire direction nets used with the BCS.

Table 4-1. Duties of personnel in the degraded FDC.

DEGRADATION 1 TACFIRE not available.	
FDO/CHIEF	Provides guidance to the computer operator for tactical fire control (BCS input). Normally, voice communications to the battalion FDC will remain, and the battalion FDC will continue to control tactical fire direction and issue the fire order. The battery FDO will guide the BCU operator in filling in the FM:RFAF message format by using the battalion fire order received by voice.
COMPUTER OPERATOR	Enters appropriate FDO instructions and required data ensuring communications with appropriate digital subscribers are maintained.
RECORDER	Acts as radiotelephone operator (RATELO) if digital communications are lost.
CHART OPERATOR	Duties remain the same as in the nongraded mode.

DEGRADATION 2 BCS down/TACFIRE up.	
FDO/CHIEF	Issues orders to use BCS manual backup. Ensures the battalion verbal fire orders are received and followed.
COMPUTER OPERATOR	Issues fire commands to the guns via vocal gun line. Operates hand-held calculator for a data check. Applies special corrections to the TACFIRE solutions and records firing data or determines platoon's firing data based on individual platoon's chart data.
CHART OPERATOR	Determines special corrections to apply to the TACFIRE center-of-battery to center-of-target solution if the battery is not massing platoons. Maintains situation map and prepares firing chart for backup.

DEGRADATION 3 BCS down/TACFIRE down.	
FDO/CHIEF	Issues orders to go to BCS manual backup. Provides guidance for tactical fire direction based on the battalion FDO's fire order.
COMPUTER OPERATOR	Issues fire commands to the guns. Operates hand-held calculator for a data check. Applies site and special corrections to the chart solution and records data.
CHART OPERATOR	Determines firing data by using the GFT fan (battery or platoons). Determines hasty special corrections, if applicable, and gives all the information to the computer.
RECORDER	Acts as RATELO. Determines site and assists computer as needed.

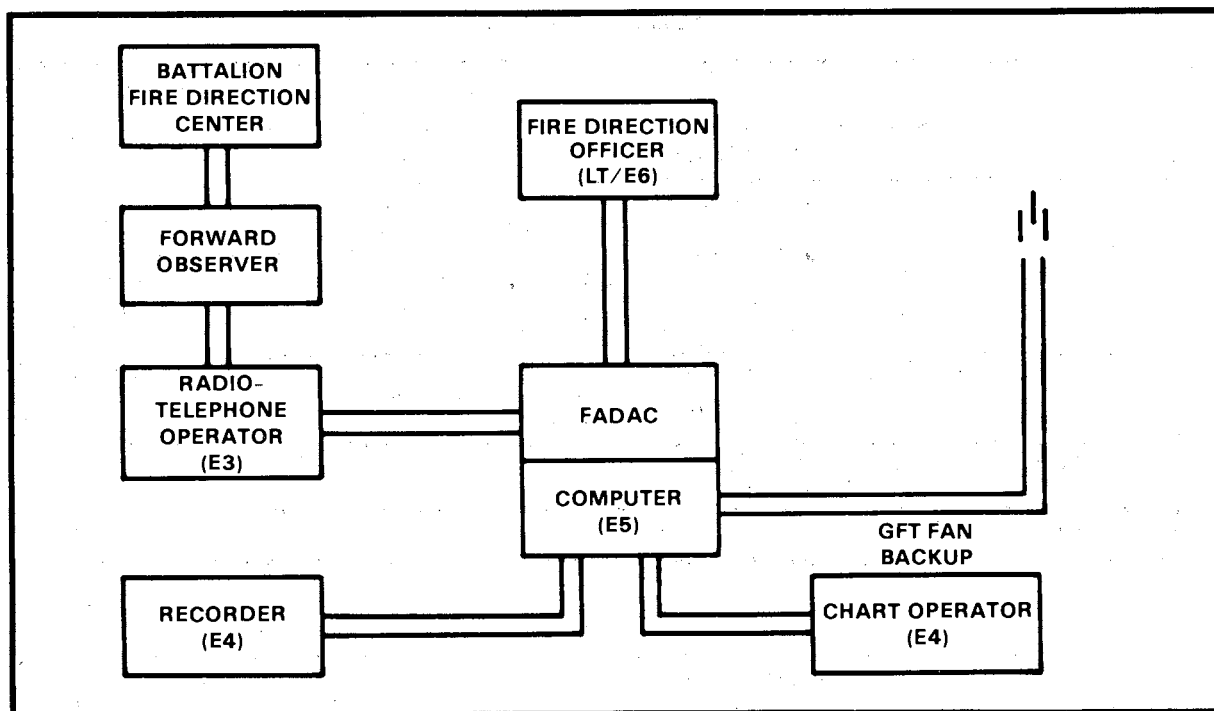


Figure 4-4. FADAC/manual fire direction center.

b. Mission Processing. A call for fire is received in the FDC by the RATELO. The FDO analyzes the target and issues instructions to the FDC on how to attack the target.

(1) The computer operator alerts the firing battery of a mission and operates FADAC, which masses the individual platoons. FADAC is the primary source for determining firing data.

(2) The chart operator concurrently determines firing data from the chart and from the GFT fan. These data provide the data check on FADAC data. The chart operator maintains the situation map and, based on guidance from the FDO, announces average site or determines and announces the site for that mission.

(3) The recorder records the mission on the record of fire and prepares the hand-held calculator to follow the mission as backup.

(4) The chart operator double-checks the FADAC firing data with his GFT-fan-determined firing data. If his center-of-battery to center-of-target solution checks within ± 3 mils deflection and quadrant

elevation and ± 0.1 fuze setting increment, he announces **CHECK**. Otherwise, he announces **HOLD**. Before firing the data, the FDO ensures that data are checked. When fire for effect is entered, platoons are massed on the target center. If individual platoon locations are plotted on the firing chart, a set of firing data for each platoon to the target may be determined instead of having hasty corrections applied to battery center data.

c. System Degradation. When the FADAC goes down, the FDC becomes a manual fire direction center. The recorder becomes the second chart operator, and the computer acts as backup with the hand-held calculator. (The manual FDC is shown in figure 4-5.)

4-3. MANUAL FDC

a. Duties of Personnel. A manual battery FDC is composed of the following:

(1) **Fire direction officer**—is responsible for the training of all FDC personnel, supervises the operation of the FDC, establishes SOP, determines method of attacking targets, and ensures accuracy of firing data sent to the guns.

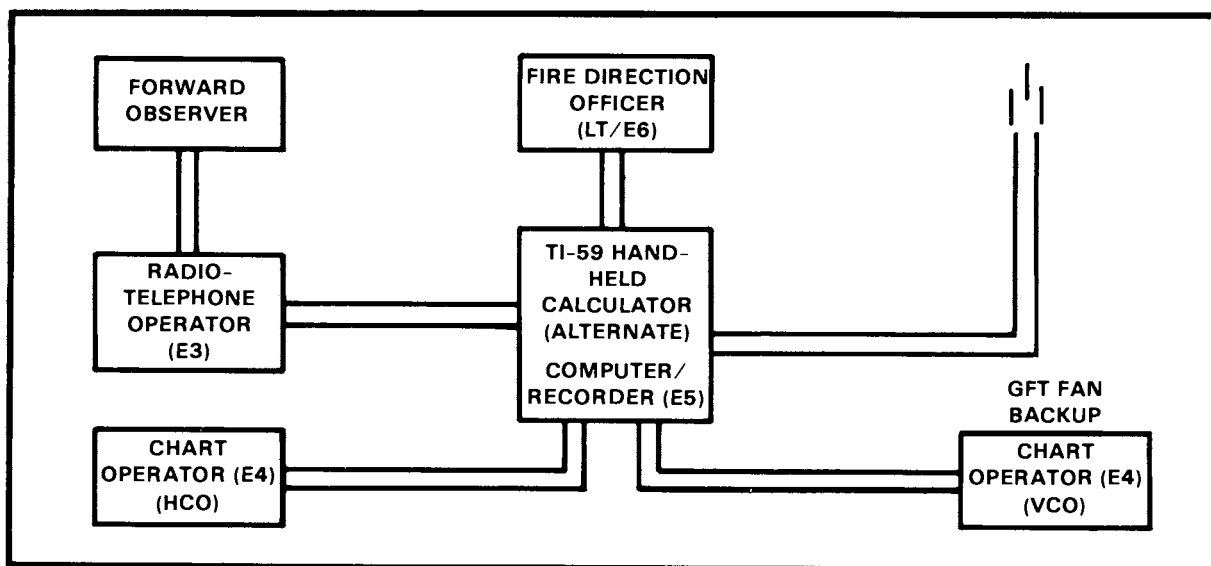


Figure 4-5. Manual fire direction center.

(2) **Chief fire direction specialist**—serves as the FDO's technical expert and functions as the FDO in the FDO's absence. He ensures that all equipment is on hand and operational, supervises computation of all data, ensures that all appropriate records are maintained, and assists the FDO as necessary.

(3) **Computer/senior fire direction specialist**—combines data provided by other personnel. He determines and announces firing data and fire commands. He also records mission-related data and other information, as directed, and determines GFT settings.

(4) **Horizontal control operator**—constructs the primary firing chart, determines and announces chart data, and checks firing data with the GFT fan.

(5) **Vertical control operator**—constructs the secondary firing chart, checks chart data, determines and announces site, and provides corrections to firing data, by platoon, from hasty correction tables, as required.

(6) **RATELO**—receives/records call for fire and maintains communications.

b. Mission Processing.

(1) A call for fire is received in the FDC by the RATELO. The FDO analyzes the

situation and decides how the target will be attacked. The chart operators plot the target, announce chart data, and then determine VI and compute and announce site. The computer determines and announces firing data (the HCO checks or holds) and announces fire commands to the guns. In fire for effect, the VCO enters hasty correction tables and announces corrections to center-to-center fire-for-effect data for each platoon.

(2) The hand-held calculator (if available) may be used as an alternate method of checking chart or firing data.

4-4. BATTALION FDC

a. Duties of Personnel. A TACFIRE-equipped battalion FDC is discussed in FM 6-1. A battalion FADAC/manual FDC is composed of the following personnel:

(1) **Fire direction officer**—supervises the FDC, analyzes targets, and issues the fire order.

(2) **Chief computer**—helps the FDO as required and trains the FDC personnel.

(3) **Assistant chief computer**—is the alternate for the chief computer.

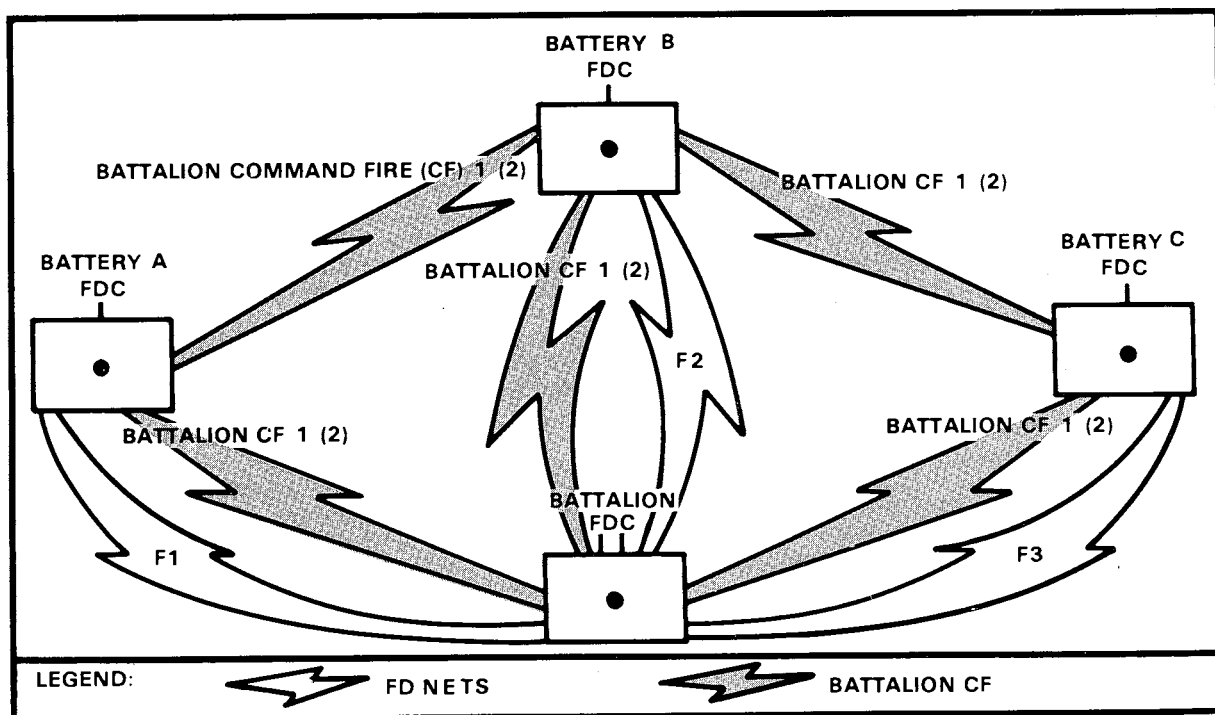


Figure 4-6. Employment of the fire direction nets (FADAC/manual).

Table 4-2. Duties of the battalion (tactical) and battery (technical) fire direction centers.

BATTALION FIRE DIRECTION CENTER	BATTERY FIRE DIRECTION CENTER
Tactical fire direction Control of mass fires Technical backup to battery FDCs Control of scheduled fires Data update	Technical fire direction Attack of other targets as assigned

(4) **Three computers**—provide primary communications between the battery and the battalion fire direction center. These people can provide technical backup to the battery if its FDC has an overload or is neutralized.

(5) **Horizontal control operator**—has the same duties as the HCO in the battery fire direction center and he operates the FADAC.

(6) **Vertical control operator**—determines and announces site and provides corrections to firing data, by platoon, from hasty correction tables as required.

(7) **RATELO**—has the same duties as those of the RATELO in the battery fire direction center.

b. Radio Communications. Figure 4-6 shows the radio nets normally employed in a FADAC/manual DS battalion. Table 4-2 summarizes duties of the two fire direction centers.

4-5. 3×8 OPERATIONS

a. FM 6-50 describes the 3×8 concept in the direct support field artillery battalion. If the battalion is equipped with TACFIRE, each four-gun platoon's FDC has a battery computer unit. As in 3×6 operations, TACFIRE provides tactical fire direction, while the BCS provides technical fire direction and control.

b. If no battalion FDC is available (autonomous operations), one of the two platoon FDCs is the controlling FDC for the entire battery. All calls for fire are sent to the controlling fire direction center. The FDO of the controlling FDC reviews the message and performs tactical fire direction. The four options he may elect are discussed below.

(1) The controlling FDO may elect not to fire the mission, and the BCU operator deletes the fire request. If the controlling FDO elects to fire the mission, he issues a fire order. The BCU operator makes entries in the FM;RFAF message format and processes the message in accordance with the fire order.

(2) The target may be engaged by the controlling platoon only. In this case, the fire request is processed as in 3x6 operations.

(3) The target may be engaged by the subordinate platoon only, and the mission is handed off. The controlling platoon's BCU must have the subordinate platoon entered in its BCS;INIT HOFFADD field. The BCU operator enters an H in the FM;RFAF handoff field and executes (EXEC) the message. The FM;RFAF is transmitted to the subordinate platoon's BCU, where it is processed as received. The observer transmits all subsequent messages to the controlling platoon. When executed, the messages are transmitted to the subordinate platoon.

(4) The target may be engaged by both platoons. The FM;RFAF and all subsequent messages are transmitted to the subordinate platoon from the controlling fire direction center. The messages are processed by both platoon fire direction centers. For adjust fire missions, one platoon must have DO NOT LOAD control until the fire-for-effect phase.

c. If TACFIRE becomes inoperable, tactical fire control will be provided by the mutual support unit (MSU) if available. Otherwise, the battalion FDC will perform manual tactical fire direction, or the battery will operate autonomously.

4-6. FIRING DATA CHECKS

There are three separate checks on firing data that must be done in the fire direction center. The FDO is responsible for seeing that all firing data sent to the weapons are technically correct and do not violate any

known restrictive measures or commander's guidance. The three checks are as follows:

a. Known Data Check. In every battery FDC, there are at least two separate firing data sources (for example, the BCS with firing charts or FADAC with firing charts). The FDO directs that all known data input into the computers be recalled and checked for accuracy by someone other than the operator who entered the data. This check ensures that all operator-applied data (locations, met, muzzle velocities, or projectile information) are correct. The ballistic computers determine firing data based on this information. The computation procedures are correct, and, if known data are correct, the firing data determined by the ballistic computers will be correct. Charts will be checked for construction accuracy as described in chapter 5.

b. Grid Location Check. Grid locations must be checked between the BCS (or FADAC) and the firing chart. The initial grid for the FM;FC, FM;RFAF, or FM;SUBS is plotted on the chart, and a target grid is oriented for direction over that point. Subsequent corrections for the mission are plotted on the chart, and the grid location of the pin is checked against the grid location in the CORD: field of the FM;SUBS message after the correction has been executed. Acceptable tolerance between the two sources should be ± 30 meters in range. The hand-held calculator may also be used to accomplish chart verification. Accuracy depends on the tolerance of the computer to the chart verification done previously. If there are unresolved discrepancies, BCS data should be used.

c. Weapon Firing Data Check. Another check may also be made as time and the situation require. During the mission, the adjusting or centermost piece ballistic computer solution can be double-checked by using graphical equipment. There will be differences in firing data solutions between the computer and the manual method. In all cases, the ballistic computers are more accurate than the manual solution, because they account for more variables. The magnitude of the difference will depend on the chart-check tolerance, the validity of the GFT setting being used, and whether or not the adjusting piece location is actually plotted on the firing chart or is displaced from the location.



*CHAPTER 5

SURVEYED FIRING CHARTS

Chart data consist of range, deflection from the firing unit to the target, and angle T. These three elements may be determined by either electronic (TACFIRE, BCS, HHC, and FADAC) or manual means. The manual method requires the construction and operation of a firing chart.

a. There are two types of firing charts that may be constructed in the FDC: the surveyed firing chart and the observed firing chart.

(1) The surveyed firing chart is a chart on which the locations of all required points (battery or platoon [3×8] positions, registration points [reg pt], and observation posts [OP]) are plotted. These locations can be based on survey or map inspection. All plotted points are in correct relation to one another and reflect actual map coordinates. Additional information such as locations of targets, maneuver

checkpoints, no-fire areas, and safety diagrams (training environment) may also be recorded.

(2) The observed firing chart is a chart on which the relative locations must be established by the adjustment of fire, hence, the name "observed firing chart." Details on construction and use of the observed firing chart are in chapter 14.

b. In the BCS- or FADAC-equipped fire direction center, a firing chart is maintained as a backup and is supplemented by a 1:50,000-scale map used to determine altitude. In the manual FDC, two firing charts are maintained. The vertical control operator maintains the backup chart and the 1:50,000-scale supplementary map with the overlay(s), and the horizontal control operator maintains the primary firing chart.

Section I

TYPES OF SURVEYED FIRING CHARTS

5-1. DESCRIPTION

A firing chart is a graphic representation of a portion of the earth's surface used for determination of distance and direction. It may be constructed by using a map, a

photomap, a grid sheet, or other material on which the relative locations of batteries, registration points, targets, and observers can be plotted. Additional positions, fire support coordinating measures, and other data needed for the safe and accurate conduct of fire may also be recorded.

5-2. CONSTRUCTION OF FIRING CHARTS

The most commonly used materials for construction of firing charts are as follows:

a. *Grid Sheet.*

(1) A grid sheet is a plain sheet of paper or plastic on which equally spaced horizontal and vertical lines, called grid lines, are printed. The intervals between these grid lines will normally create 1,000-meter grid squares on a scale of 1:25,000. This provides the best compromise between accuracy and convenience and is therefore the scale for which standard plotting equipment is graduated. The location of all points plotted on the grid sheet must be determined by either survey, map inspection, or firing.

(2) The grid sheet is numbered to correspond to the map area of the zone of action of the supported force. The lower left-hand corner is assigned easting and northing coordinates by the FDO, and the direction of the long axis (east-west or north-south) is designated. The grid sheet is numbered with a 4H pencil. The rightmost and topmost grid lines are not numbered.

b. Map. A map is a graphic representation, drawn to scale, of a portion of the earth's surface. Only maps based on accurate ground

survey should be used for construction of firing charts. If the map scale is other than 1:25,000, the range readings obtained from plotting equipment must be adjusted. For example, if a 1:50,000-scale map is used, the ranges obtained from the range-deflection protractor (RDP) must be doubled. Deflections and azimuths are not affected. If a map is not based on accurate and adequate ground survey control, it should be used only to obtain approximate locations and vertical control to supplement a grid sheet firing chart.

c. Photomap. A photomap is a reproduction of an aerial photograph or a mosaic of aerial photographs on which grid lines, marginal information, and place names are added. A photomap must not be considered exact until its accuracy has been verified. Errors caused by tilt, distortion caused by relief, and errors caused by poor assembly may be present in photomaps. If points cannot be located on the photomap by inspection, the scale must be determined before they can be located on the photomap by survey. Normally, vertical control can be established by estimation only. The determination of the scale of vertical control of photographs is in FM 21-26 and TM 30-245. Some photomaps have spot altitudes, but interpolation for altitude is difficult and inaccurate.

Section II PLOTING EQUIPMENT AND PREPARATION OF FIRING CHARTS

5-3. CHART OPERATION

To ensure the accuracy of the data shown on the firing chart, FDC personnel should construct and plot from a standing position directly above the chart. Plotting pins must be kept perpendicular to the firing chart. The firing chart should be kept as clean as possible at all times. If there are two charts in the FDC, they must be checked against each other for accuracy. If a chart is the backup for another system, it should be verified against that system for accuracy. Details on this procedure are in section III.

5-4. EQUIPMENT

The following equipment is used in the preparation of firing charts:

a. 6H Pencil. The 6H (hard lead) pencil, sharpened to a wedge point (fig 5-1), is used to draw all lines from which measurements will be made.

b. 4H Pencil. The 4H pencil, sharpened to a conical point (fig 5-2), is used to letter and to accentuate tick marks.

c. Plotting Pins. Plotting pins are used to mark indexes and temporary positions on the firing chart. On a 1:25,000-scale chart, the thickness of the plotting pin equals 20 meters.

d. Aluminum Plotting Scale. The aluminum plotting scale (fig 5-3) is a square-shaped scale used to plot or determine

grid coordinates. The scale is graduated in meters and yards at scales of 1:25,000 and 1:50,000. The meters scale is graduated every 20 meters, and locations can be visually interpolated to the nearest 1 meter. Care must be taken not to confuse the meters and yards scales on this instrument. Paragraph 5-5 details the procedure for plotting points with the aluminum plotting scale.

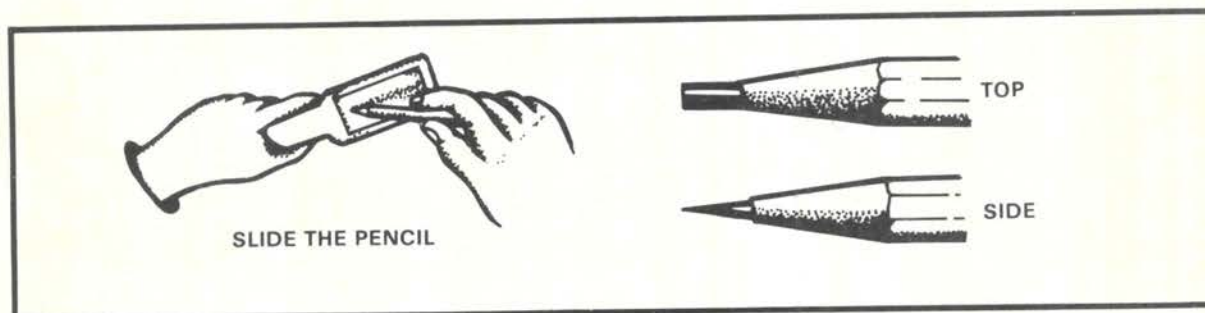


Figure 5-1. The 6H pencil (wedge point).

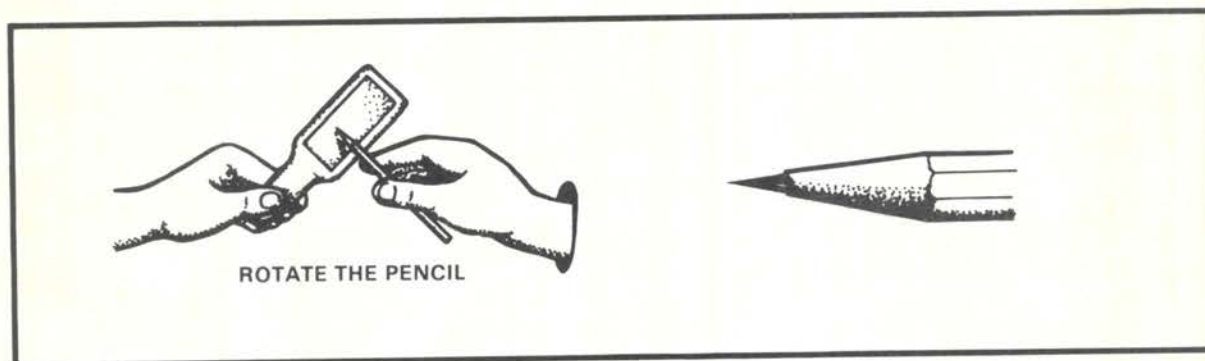


Figure 5-2. The 4H pencil (conical point).

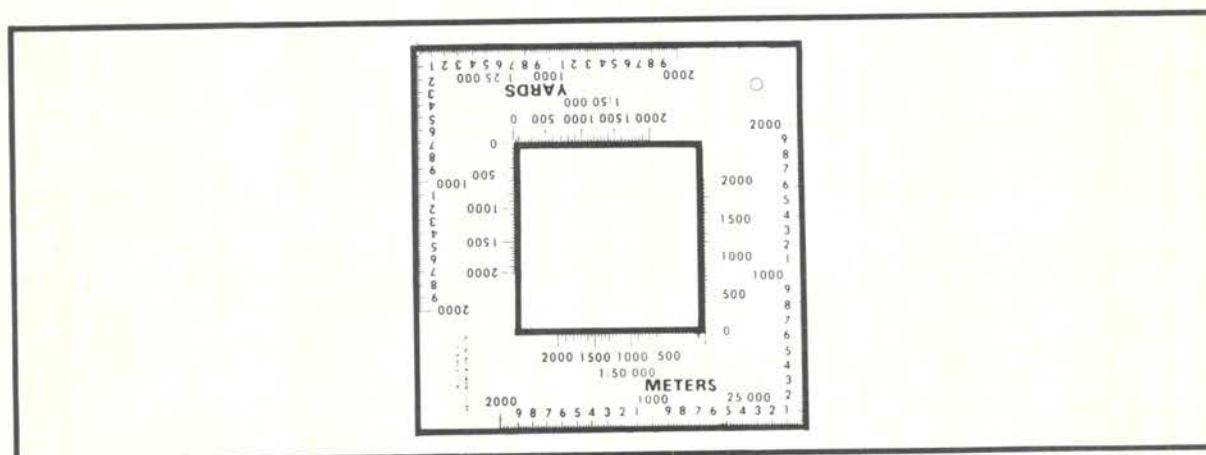


Figure 5-3. Aluminum plotting scale.

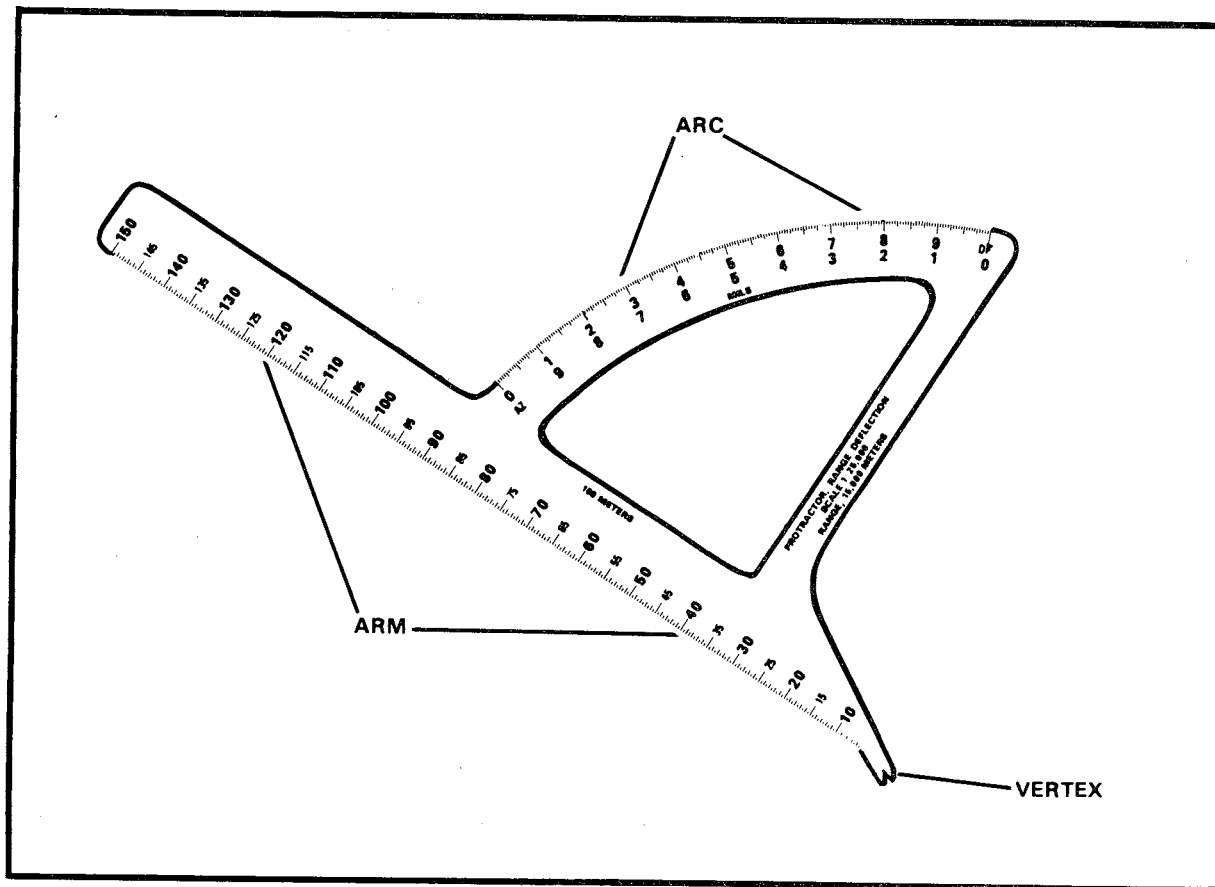


Figure 5-4. Range-deflection protractor.

e. Range-Deflection Protractor.

The range-deflection protractor (fig 5-4) is used to measure angles in mils and distances in meters. It is used to measure range and deflection from a firing unit to a target and direction and distance from an observer to a target.

(1) The left edge of the instrument is the arm and is used to measure range or distance. It is graduated in 50-meter increments and labeled every 500 meters on a scale of 1:25,000. Ranges and distances are visually interpolated to an accuracy of 10 meters.

(2) The 1,000-mil arc of the RDP is graduated in 5-mil increments. The 50-mil increments are indicated by longer graduations and are permanently numbered. The arc is visually interpolated to an accuracy of 1 mil.

(3) There are four different RDP models. They differ by maximum range of the arm (12,000, 15,000, 25,000, and 30,000 meters).

f. Target Grid.

(1) **Description.** The target grid is a circular paper or plastic device on which grid lines are printed (DA Form 4176 [Target Plotting Grid Field Artillery Graduated in Mils and Meters Scale 1:25,000]). These lines match the scale of the 1:25,000 firing chart, dividing a 1,000-meter grid square into 100-meter squares. An azimuth scale is printed around the outside edge of the target grid. It is graduated in 10-mil increments and is numbered every 100 mils. An arrow extends across the center of the target grid and is used to indicate the observer-target (OT) line (or other line of known direction). The target grid should be labeled as shown in figure 5-5. Tape may be applied to the reverse side of the target grid to prevent the center hole from becoming enlarged.

(2) **Purpose and Use.** The target grid is used for plotting the positions of targets located by shift from a known point

(para 5-10c), plotting subsequent corrections, and determining angle T (section III).

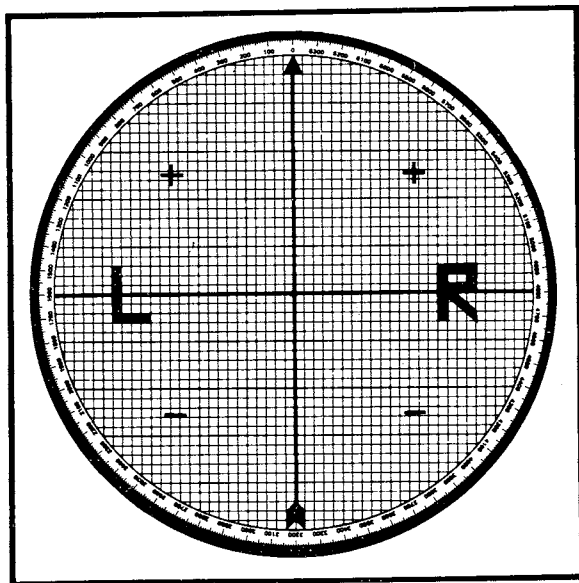


Figure 5-5. Labeling the target grid.

5-5. POINT PLOTTING

To plot points that have been located by grid coordinates, proceed as follows:

a. Grid Lines 1,000 Meters Apart.

(1) Place a plotting pin in the upper right-hand corner of the grid square where the point is to be plotted (for example, grid 60478 32859 [**A** , fig 5-6]). This pin will prevent the inadvertent plotting of the point in the wrong grid square.

(2) Place the aluminum plotting scale along the left edge of the grid square with the 0 of the scale at the lower left-hand corner of the grid square (**B** , fig 5-6).

(3) Slide the scale to the right. Read easting on the scale by using the north-south grid line as an index (**C** , fig 5-6).

(4) With the bottom edge of the scale aligned precisely on the east-west grid line, plot the northing on the vertical scale with a plotting pin. This is the plotted location (**D** , fig 5-6).

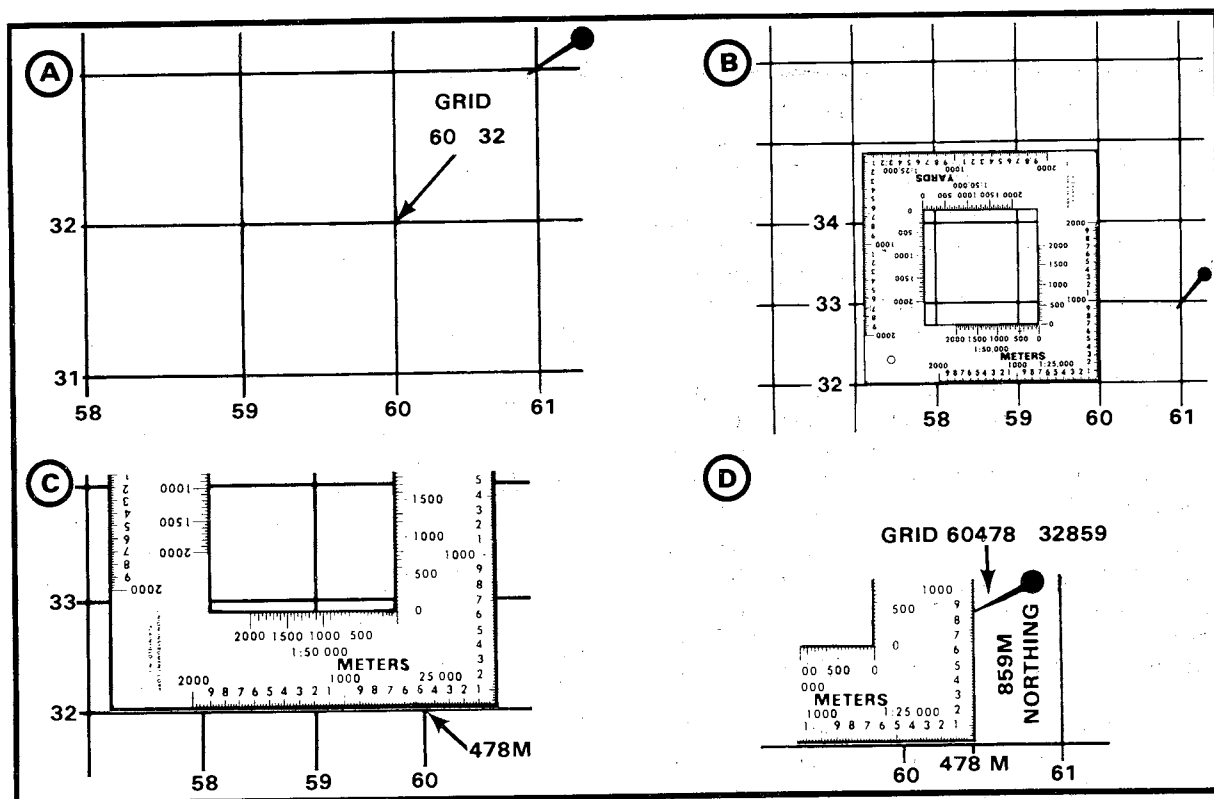


Figure 5-6. Plotting with the aluminum plotting scale.

b. Grid Lines Other Than 1,000 Meters Apart.

(1) When grid squares are *smaller than normal*, plot the easting or northing by inclining the aluminum plotting scale so that the 0 of the scale is on one grid line and the 1000 is on the other (fig 5-7). The four-point plotting technique (para (3) below) must be used.

(2) When grid squares are *larger than normal*, incline the aluminum plotting scale so that the 0 of the scale is on one grid line and 2000 is on the other (fig 5-8). Multiply the distance to be plotted by 2, and insert a pin at that distance on the scale. For example, for an easting of 62681, place the pin at (62)1362 on the scale.

(3) In both cases, only easting or northing can be plotted at one time. Therefore, the following four-point plotting technique must be used to plot a critical point when grid lines are less than 1,000 meters apart.

(a) Locate the grid square in which the point is to be plotted.

(b) Using plotting pins and the aluminum plotting scale, plot the easting grid in the grid squares above and below the grid square in which the point is to be located. Remove the pins and connect the points with a fine line drawn with a 6H pencil through the center of the pinholes (fig 5-9).

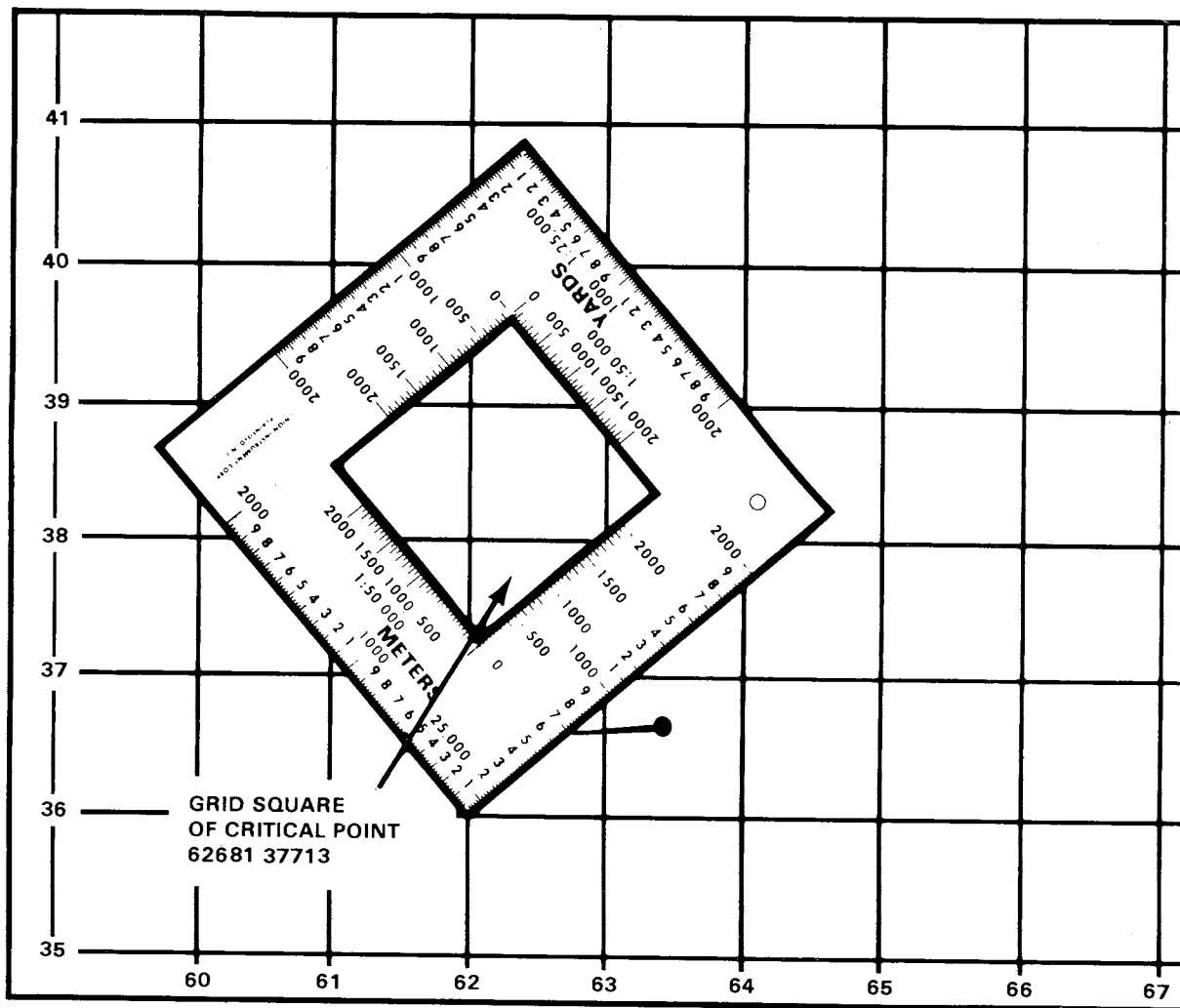


Figure 5-7. Grid squares smaller than normal.

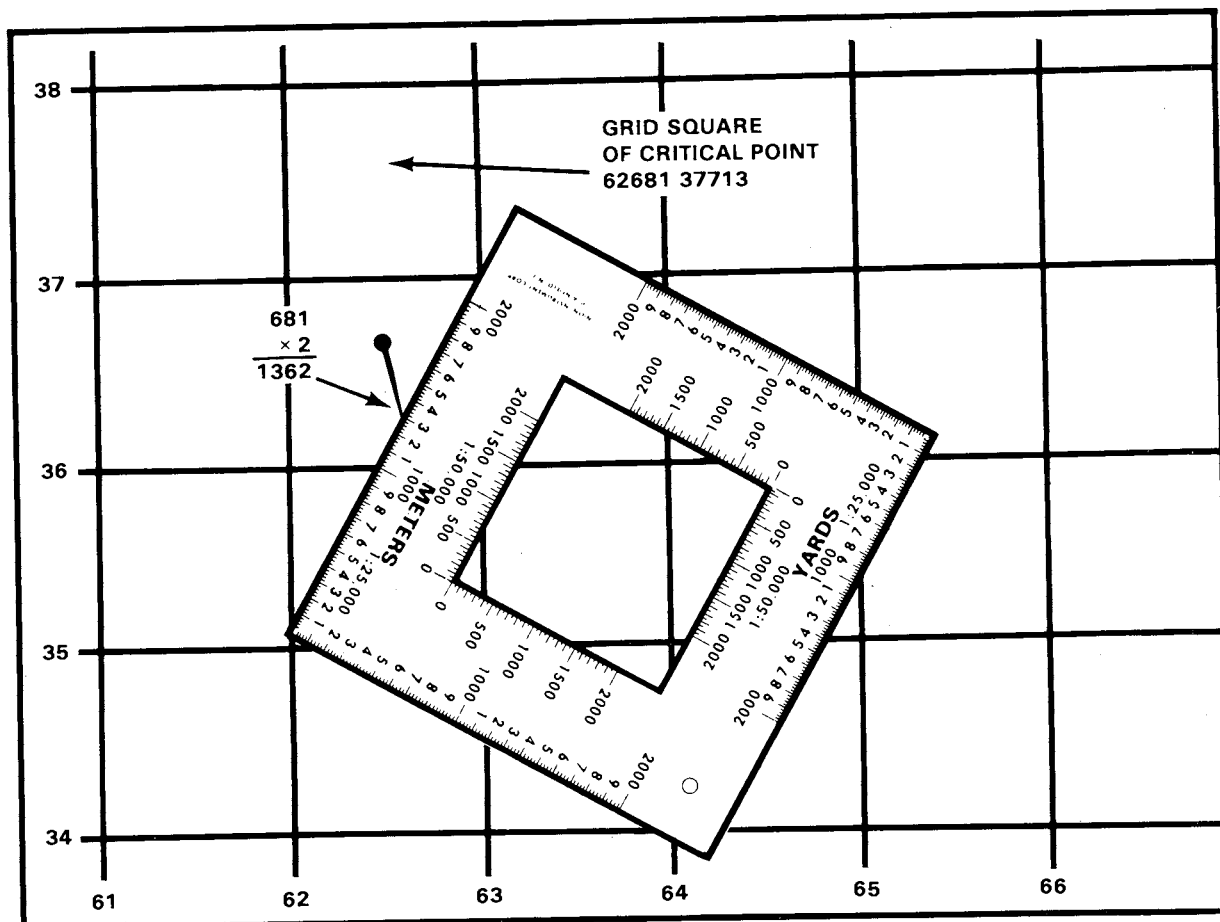


Figure 5-8. Grid squares larger than normal.

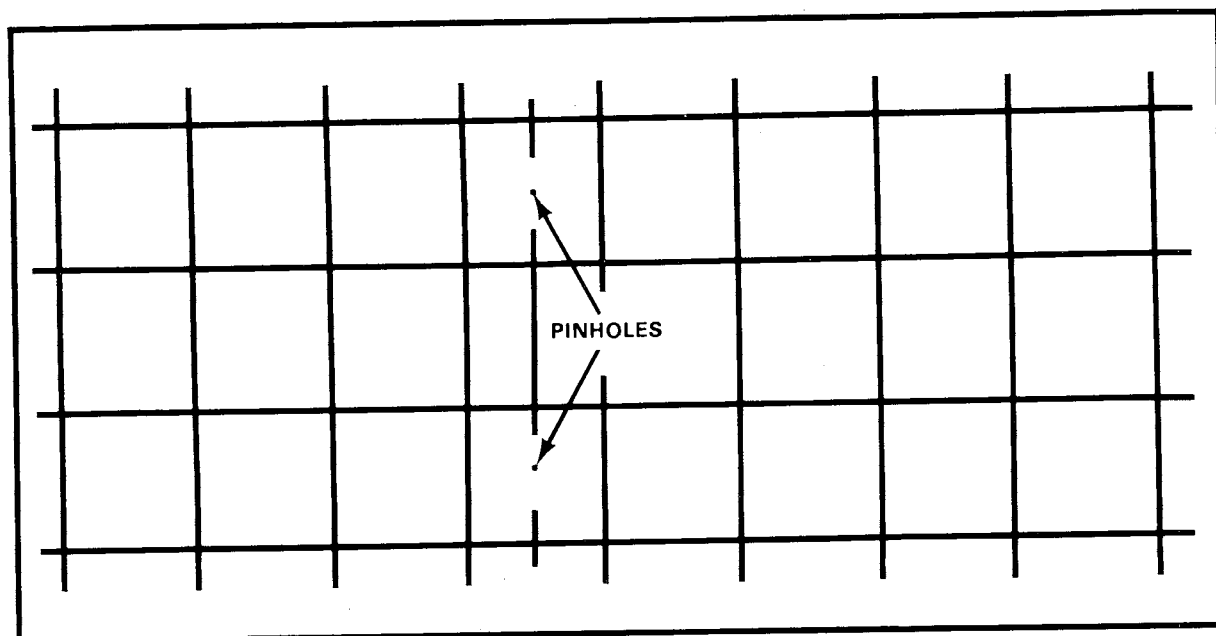


Figure 5-9. Plotting the grid easting.

(c) Plot the grid northing in the grid squares to either side of the grid square in which the point is to be located (fig 5-10). Connect the pinholes with a line drawn with a 6H pencil.

(d) With a plotting pin, mark the point where the two lines meet (fig 5-11). Erase the fine lines and identify the location with a tick mark (para 5-6) (fig 5-12).

(e) The four-point plotting technique may also be used on a standard 1:25,000-scale firing chart. Easting is plotted along the east-west grid lines bordering the grid square where the point is located. Northing is plotted on the north-south grid lines bordering the grid square. Only when accuracy is more important than speed should this technique be employed.

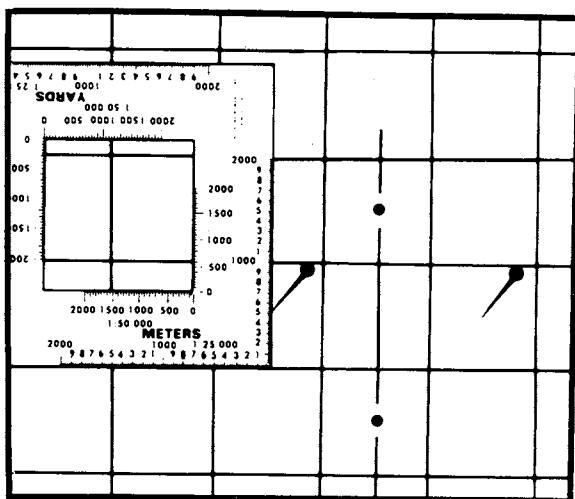


Figure 5-10. Plotting the grid northing.

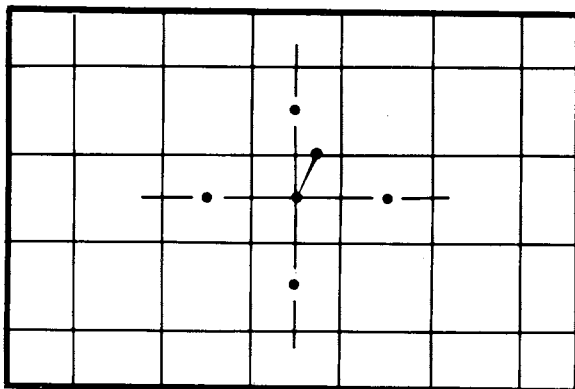


Figure 5-11. Marking the point where the two lines meet.

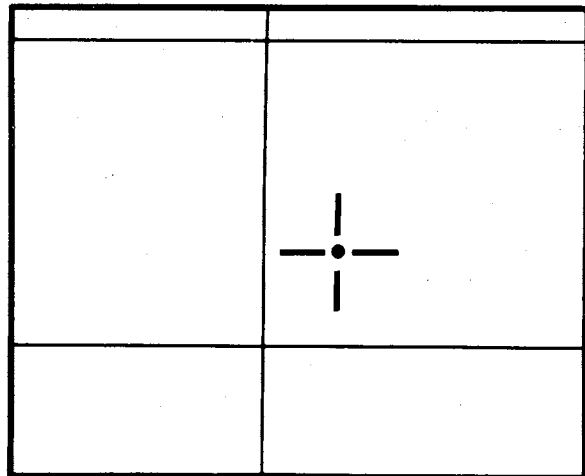


Figure 5-12. Identifying the location with a tick mark.

5-6. TICK MARKS

The tick mark is the symbol used to mark and identify the essential locations on a firing chart.

a. The tick mark is constructed in the form of a cross, with each arm beginning 40 meters from the pinhole on the chart and extending 150 meters in length (1:25,000 scale) (fig 5-13).

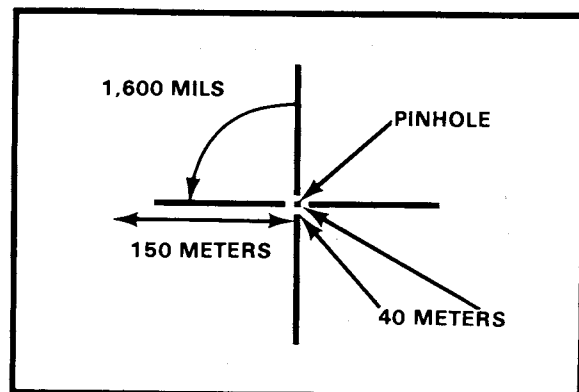


Figure 5-13. Drawing the tick mark.

b. The lines of the tick mark are drawn parallel to the grid lines unless the labeling interferes with a previously labeled tick mark (A, fig 5-14) or the plotted point falls on or near (within 80 meters) a grid line (B, fig 5-14). In these cases, the tick mark is plotted on an 800-mil (45°) angle to the grid line. All tick marks are drawn with a 4H pencil except

those for targets located by firing, which are drawn in red, and for maneuver checkpoints, which are drawn in blue.

c. The identification of the point is placed in the upper right quadrant. The installation or activity is designated in the following manner:

(1) **Battery.** The letter designation is shown in the appropriate color (Ⓒ, fig 5-14) (that is, A-red, B-black, C-blue, D-orange). If more than four batteries are shown, the color coding starts over again with red. If the pieces of the battery are widely dispersed, it may be necessary to plot piece or platoon locations (for example, platoons in 3x8 operations). Platoon or piece designations should be labeled by using the battery's color code.

(2) **Radar.** The military symbol is shown in green (Ⓓ, fig 5-14).

(3) **Observation post.** The military symbol for an observer and the call sign number which will be used by the observer to identify himself are shown in black (Ⓔ, fig 5-14). If the observation post is assigned a number, that number is shown in black in

place of the symbol and call sign number (for example, O1).

(4) **Registration point.** The number assigned to the registration point is shown in black (for example, REG PT 2 [Ⓕ, fig 5-14]).

(5) **Target.** The assigned target number is shown in black (for example, CB2131 [Ⓖ, fig 5-14]).

(6) **Checkpoint.** The checkpoint tick mark is shown in blue, while its number is shown in black and circled (for example, ① [Ⓗ, fig 5-14]).

d. The altitude (alt), in meters, of the plotted point is placed in the lower left quadrant in black (Ⓑ through Ⓘ, fig 5-14).

e. If the plotted point has been fired on, the fuze used in fire for effect may be placed in the lower right quadrant (Ⓘ, fig 5-14).

f. If the plotted point has been fired on with high-angle (HA) fire, the letters HA may be placed in the upper left quadrant. The charge that was used in the mission can also be indicated (Ⓘ, fig 5-14).

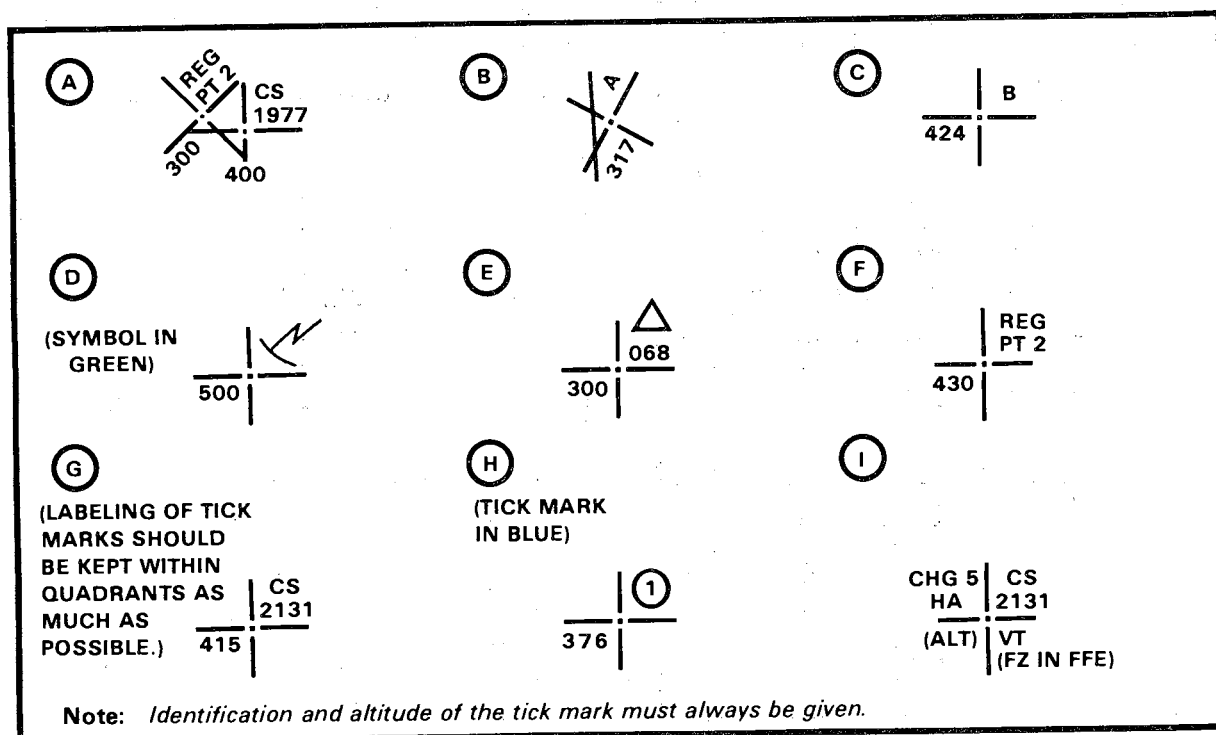


Figure 5-14. Tick marks.

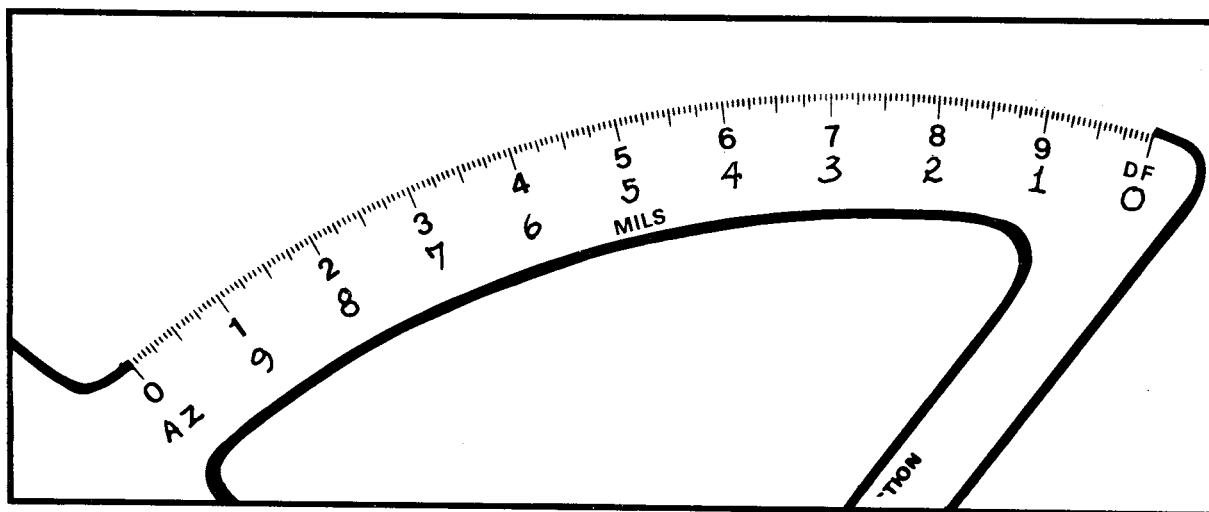


Figure 5-15. Numbering on the range-deflection protractor.

5-7. CONSTRUCTION OF AZIMUTH INDEXES

a. Azimuth indexes are constructed for points located on the firing chart from which the polar plot method (para 5-10) of target location may be expected (for example, observation posts and radar sites). The RDP must be prepared by numbering the 100-mil graduations in black as shown in figure 5-15.

b. Azimuth (az) is always read as four digits. The first digit (thousands of mils) is read from an index that is drawn on the firing chart. The last three digits are read from the arc of the range-deflection protractor.

c. Azimuth indexes are constructed on the firing chart at 1,000-mil intervals throughout the target area except the 6000 and the 0 indexes, which are 400 mils apart (fig 5-16).

(1) Place the vertex of the RDP against the pin in the observation post or radar location, and align the arm parallel to a convenient grid line. If you are using a north-south grid line, plot the easting of the observer with a plotting pin. If you are using an east-west grid line, plot the northing of the observer in a similar manner. When the RDP is aligned with the vertex at the observer and the arm against the pin, a reference line is established at an azimuth of 0 (north), 1600 (east), 3200 (south), or 4800 (west). It is not drawn.

(2) In (1) above, the RDP was oriented in a cardinal direction. To establish the

azimuth index, place a pin opposite the number on the arc corresponding to the last three digits of the azimuth in which the arm of the RDP is oriented. The location of the pin represents an index. Its value is the value of the first digit of the azimuth in which the arm of the RDP is oriented. If the arm is oriented toward north, two azimuth indexes will be constructed, since north corresponds to 6400 and 0 mils (fig 5-16). These will be the 6000 and 0 indexes. Table 5-1 summarizes indexing procedures for all orientations of the range-deflection protractor.

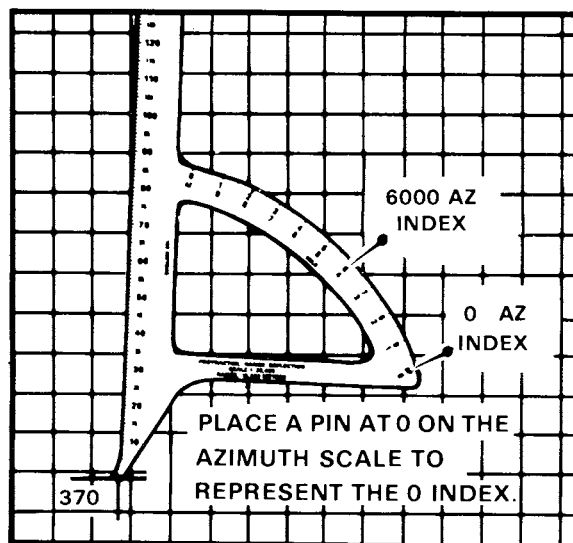


Figure 5-16. Plotting the 6,400-mil and 0-mil temporary azimuth indexes.

Table 5-1. Indexing procedures.

If RDP is oriented NORTH (6,400 mils or 0 mils),
 (1) Place pin opposite 400 on ARC; INDEX is 6000.

(2) Place pin opposite 0 on ARC; INDEX is 0.
 If RDP is oriented EAST (1,600 mils),
 place pin opposite 600 on ARC; INDEX is 1000.
 If RDP is oriented SOUTH (3,200 mils),
 place pin opposite 200 on ARC; INDEX is 3000.
 If RDP is oriented WEST (4,800 mils),
 place pin opposite 800 on ARC; INDEX is 4000.

(3) To replace the plotting pin with a constructed index, move the RDP so the left edge of the arm is against the pin (A, fig 5-17). Remove the pin and, with a 6H pencil, draw the azimuth index through the center of the pinhole (B, fig 5-17). The index is a fine line extending 1 inch on each side of the pinhole. For example, in (B), figure 5-17, this line can be constructed by drawing a line from range 8250 to range 9520 along the arm of the RDP. Beginning one-eighth inch beyond the pinhole, label the index with its identification and azimuth value (for example, 01AZ0 [C, fig 5-17]). Lettering is green for the radar symbol and its azimuth labels and black for observation posts and their azimuth labels.

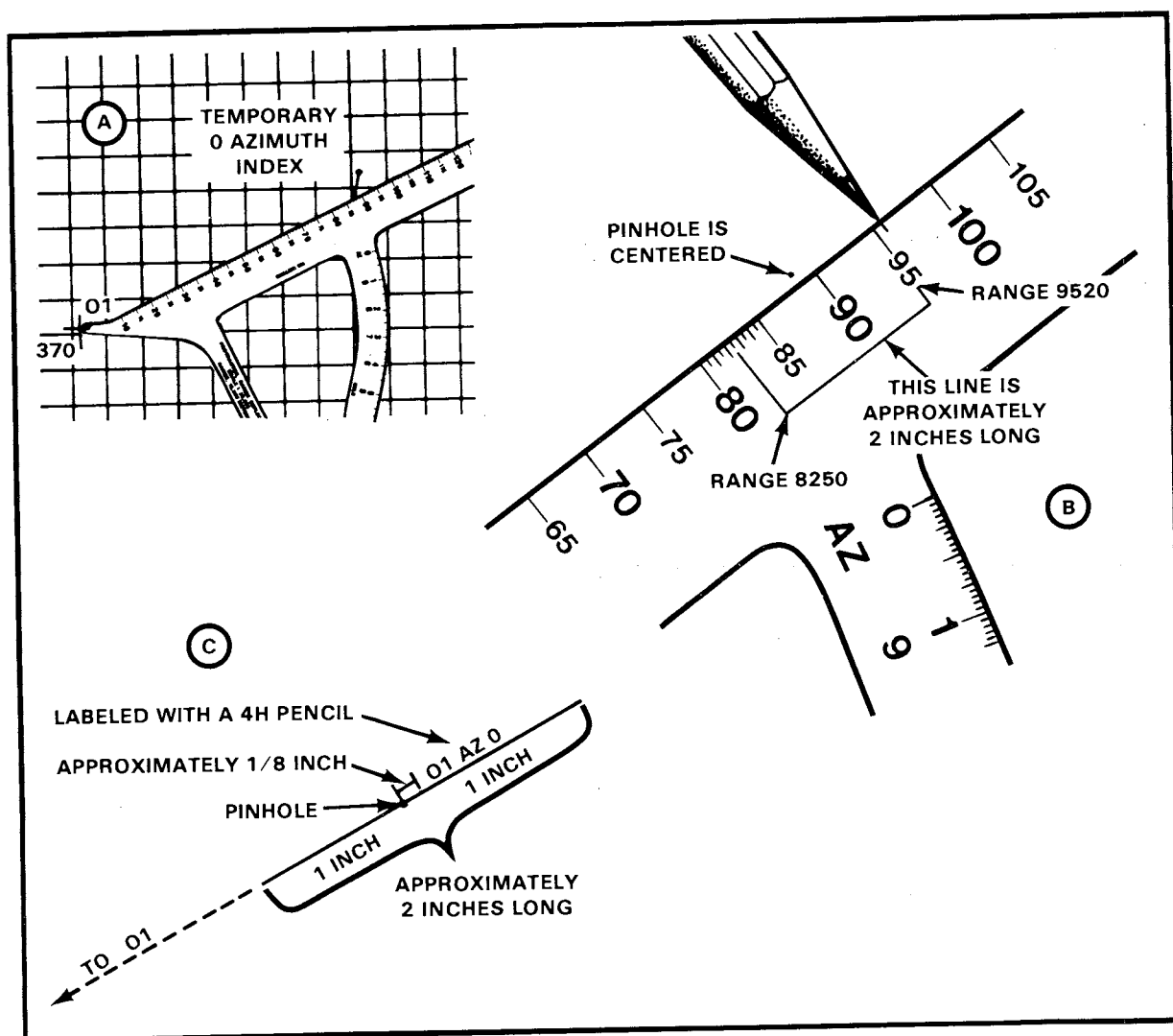


Figure 5-17. Preparing an index.

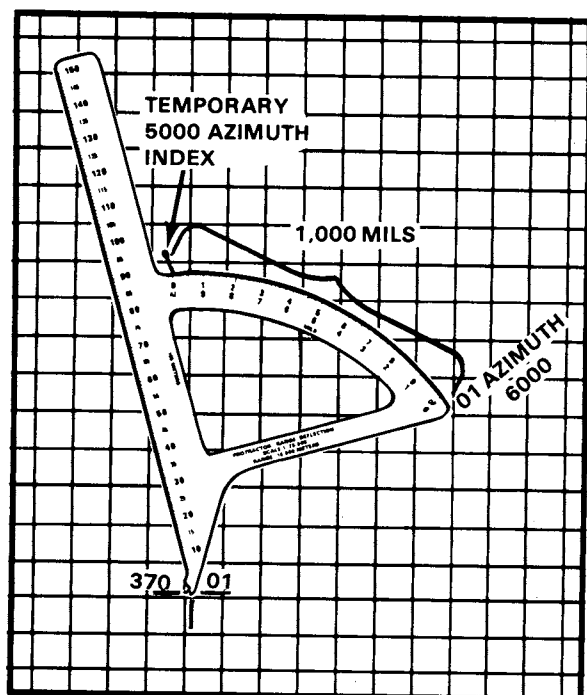


Figure 5-18. Constructing other azimuth indexes.

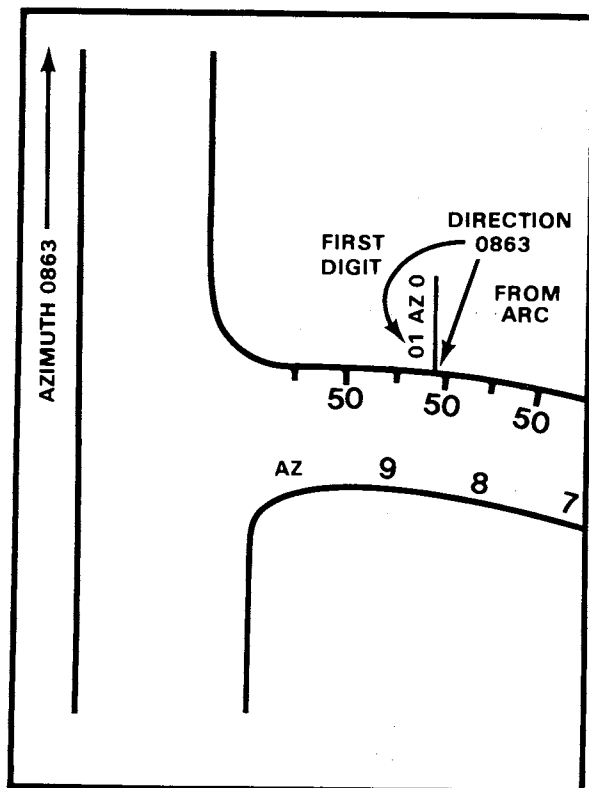


Figure 5-19. Measuring the azimuth.

(4) Other azimuth indexes can be constructed by measuring successive 1,000-mil increments to the left and right of the initial index. To locate an index for 2,000 mils, place a pin 1,000 mils right of the index for azimuth 1000. The arc of the RDP represents 1,000 mils. To locate an azimuth index for 5,000 mils, place a pin 1,000 mils left of the index for 6,000 mils (fig 5-18).

d. The value of the measured azimuth is the sum of the azimuth marked on the azimuth index plus the value read on the arc opposite the index (fig 5-19). In this example, the azimuth is 0863.

5-8. CONSTRUCTION OF DEFLECTION INDEXES

Direction from a battery to a target normally is measured and announced in terms of deflection. Deflection is the horizontal clockwise angle measured from the line of fire (or the rearward extension of the line of fire) to a designated aiming point, with the vertex at the instrument. The RDP must be prepared to measure deflection by numbering the graduations of the arc in red as shown in figure 5-20.

a. The deflection index is used with the RDP to determine chart deflection. The deflection index is constructed as follows:

(1) With the vertex of the RDP against the pin in the battery position, orient the left edge of the arm in the direction of the battery's azimuth of lay. Follow the procedure outlined in paragraphs 5-7c(1) and (2), and place a pin in the chart as a temporary azimuth index. In figure 5-21, the RDP is oriented to the nearest cardinal direction (1,600 mils) and a pin is placed opposite 600 on the azimuth scale. This is the 1000 index. Now move the RDP until the last three digits of the azimuth of fire (read on the azimuth scale of the RDP) are opposite the pin. The left edge of the RDP is now oriented in the direction of the battery azimuth of lay. Figure 5-22 shows the RDP oriented on an azimuth of lay of 1,900 mils.

(2) For the M100-series sight, the common deflection is 3,200 mils. The firing chart must be constructed so that the azimuth of lay corresponds to the common deflection.

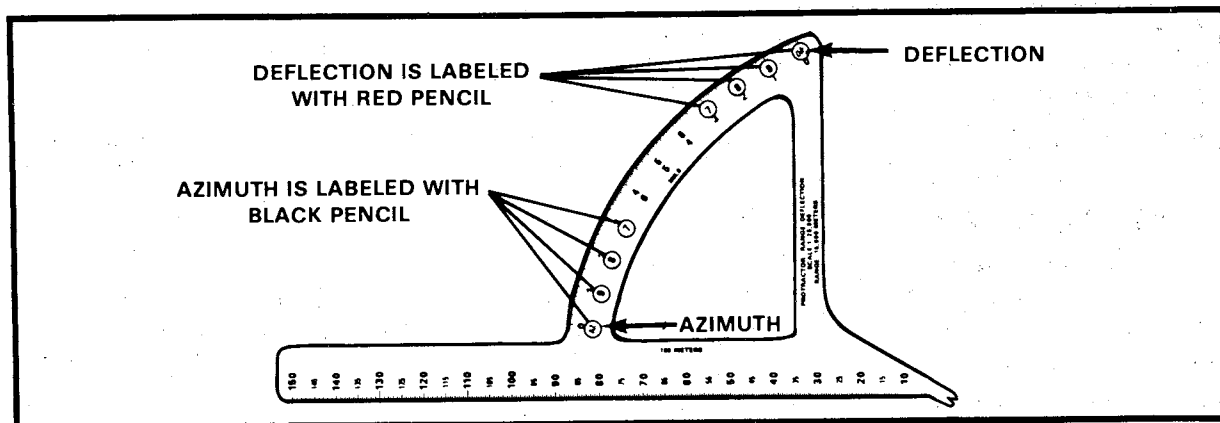


Figure 5-20. The range-deflection protractor prepared for measurement of deflection.

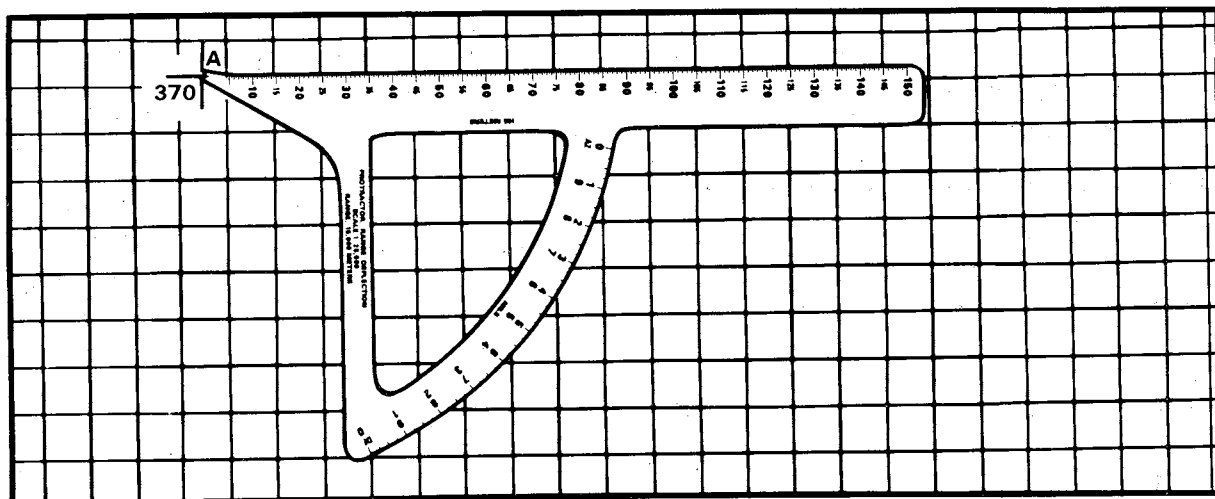


Figure 5-21. Range-deflection protractor oriented to the east.

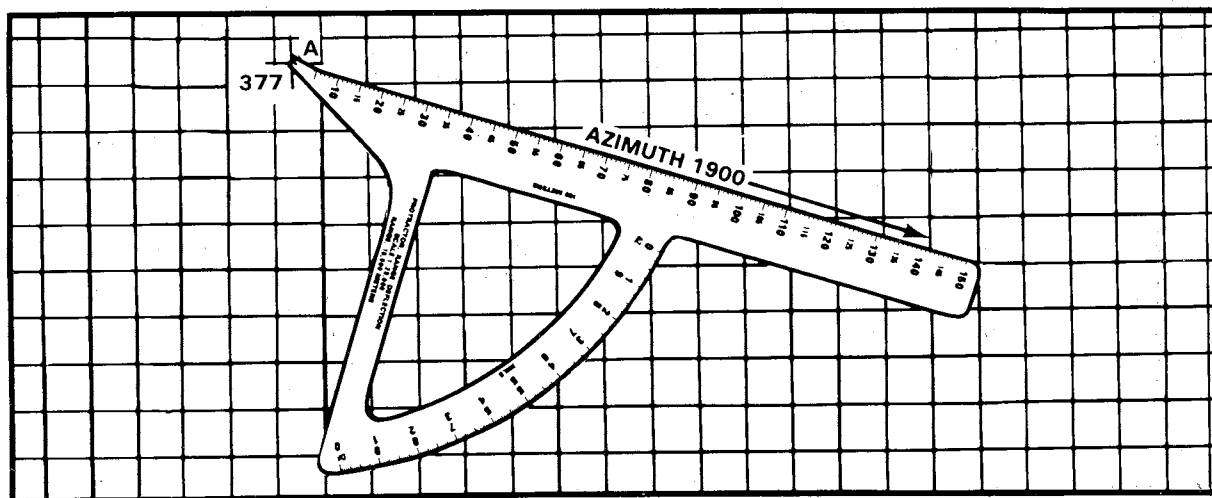


Figure 5-22. Range-deflection protractor oriented on azimuth of lay.

To do this, orient the RDP on the azimuth of lay (as above), and place a pin opposite the 200-mil graduation on the deflection scale (fig 5-23). This is the 3,000-mil index for deflection. Move the RDP so the left edge of the arm is against the pin and draw a fine line (with 6H pencil) along the range scale from ranges 8250 to 9520 on the RDP. Label this index with the appropriate color. Draw the arrowhead as shown in figure 5-24 in the appropriate color

and one-eighth inch above the pinhole. For the M12-series sight, with a common deflection of either 2400 or 2800, the pin is placed at 4 or 8, respectively, and the index is labeled 2.

b. Locate supplementary indexes by constructing indexes 1,000 mils left and right of the primary index (fig 5-25).

c. Deflection indexes will be constructed for all firing units plotted on the firing chart.

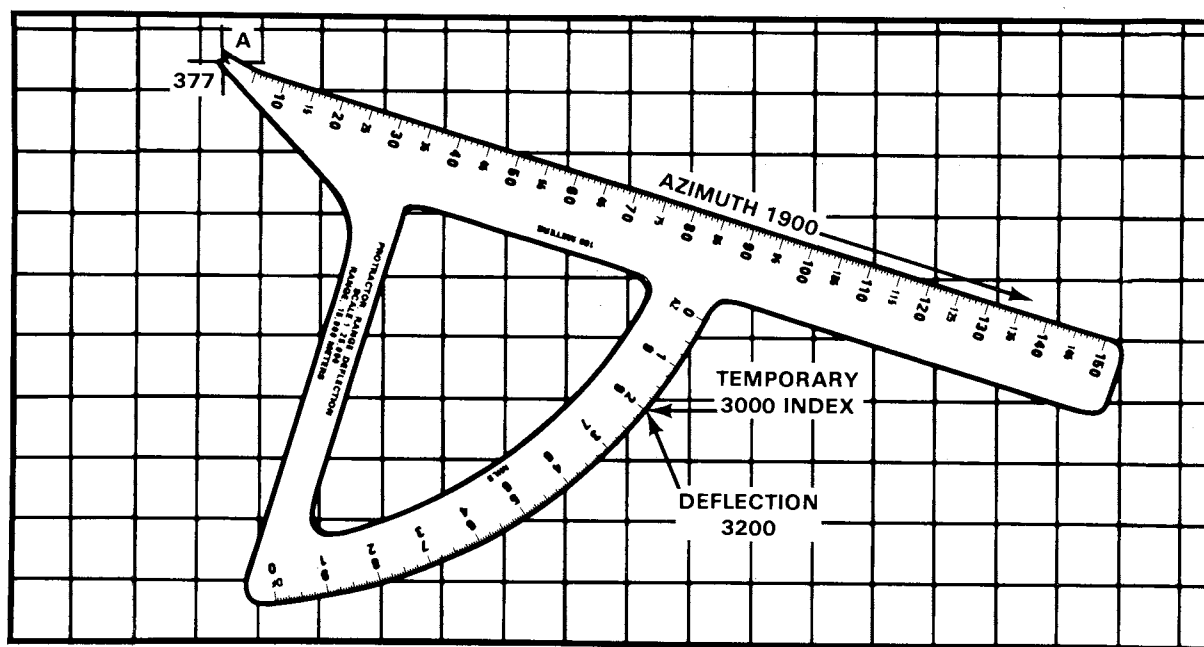


Figure 5-23. Construction of a common deflection index.

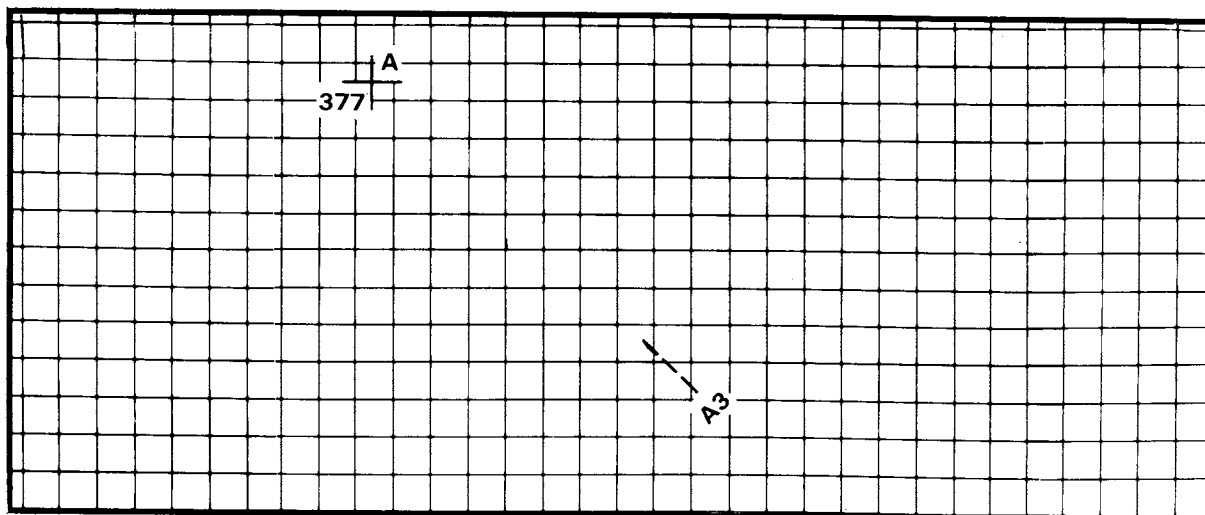


Figure 5-24. Construction of the primary deflection index.

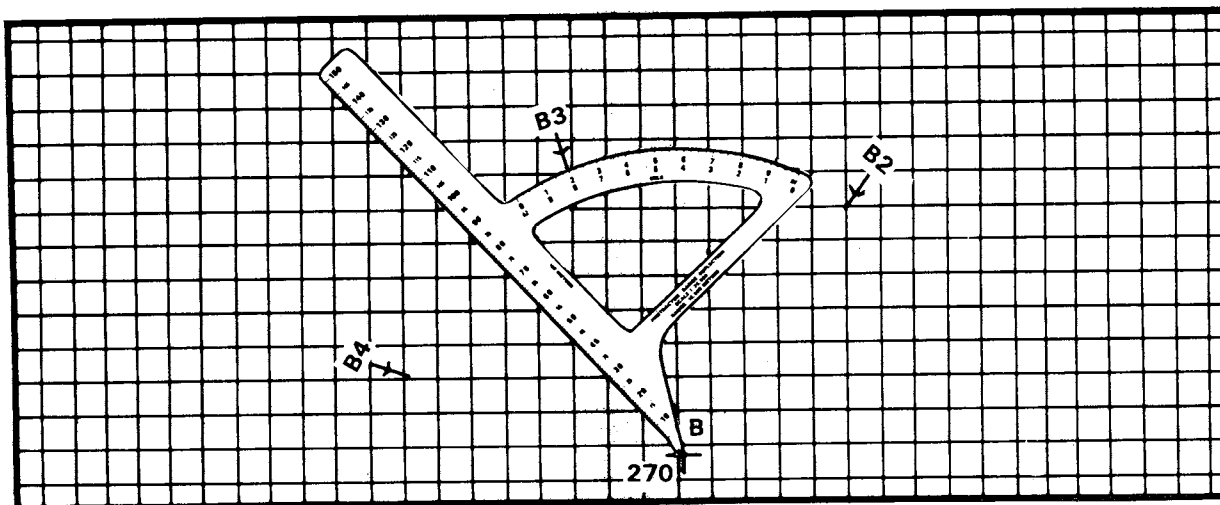


Figure 5-25. Construction of supplementary deflection indexes.

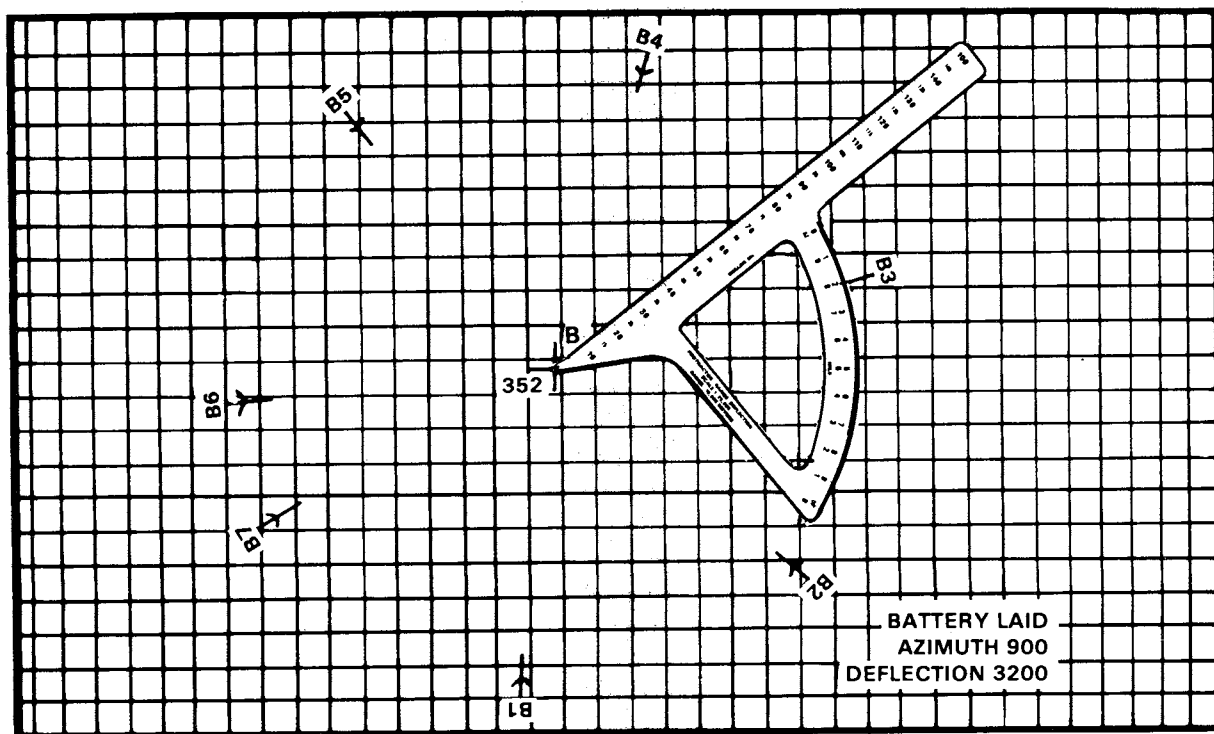


Figure 5-26. The 6,400-mil firing chart.

5-9. 6,400-MIL CHARTS

When firing in a 6,400-mil sector is required, the firing units are plotted in the center of the firing chart. The indexes are constructed and numbered as shown in figure 5-26. Locally fabricated larger charts may be necessary to achieve the maximum range throughout the 6,400 mils.

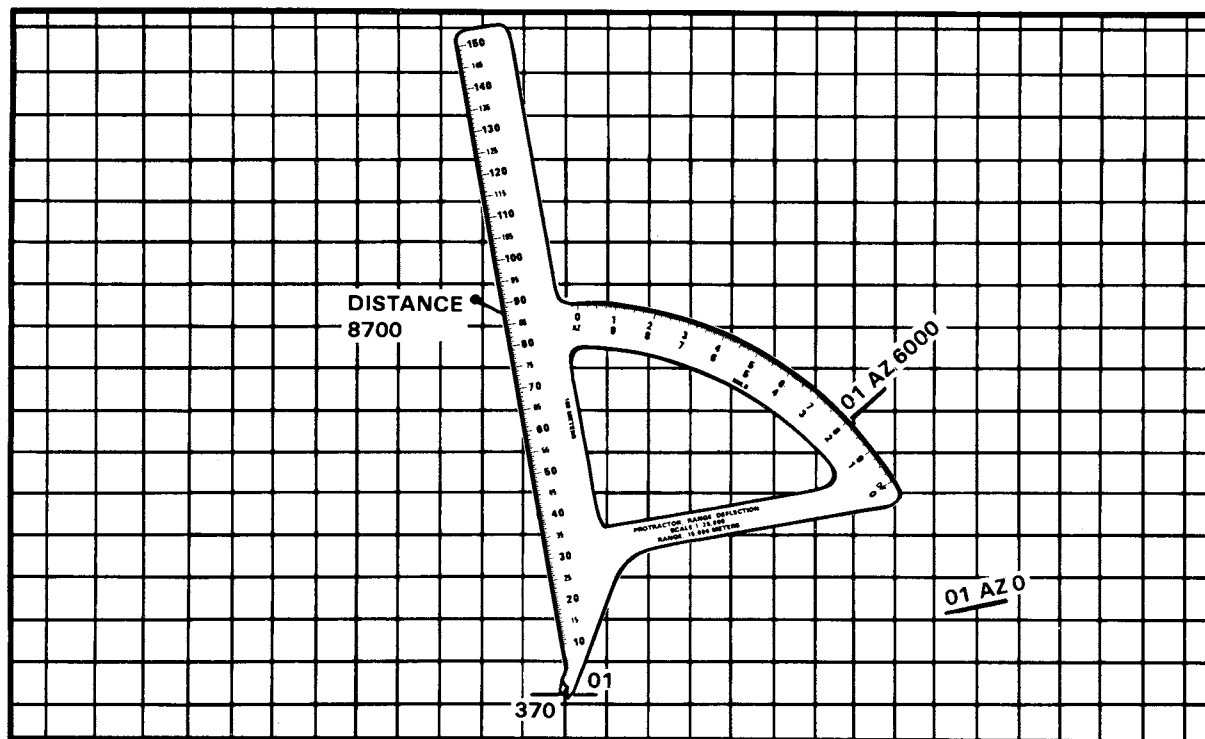


Figure 5-27. Polar plot the target location.

5-10. METHODS USED IN PLOTTING TARGETS

a. Grid Coordinate. To plot points located by the grid coordinate method, follow the procedures outlined in paragraph 5-5.

b. Polar Plot. To plot points located by the polar method, proceed as follows:

(1) Place the vertex of the RDP against the pin at the OP, with the arc opposite the proper azimuth index.

(2) Align the RDP in the direction reported by the observer opposite the azimuth index. In figure 5-27, the observer (O1) reported a direction of 6200.

(3) Place a pin along the left edge of the arm of the RDP at the reported distance. This is the location of the target. In figure 5-27, the observer reported a distance of 8,700 meters.

c. Shift From a Known Point. A shift from a known point target is located relative to a known point by using OT direction, a lateral shift, a range shift, and a vertical

shift. The following method is used in plotting a target location:

(1) Place the center of the target grid over the location of the known point on the firing chart and fix it in position with a pin. To orient the target grid, move the arrow parallel to a north-south grid line, with the arrow pointing north. Place a pin opposite 0 on the scale. Then, rotate the target grid until the OT direction is opposite the pin. The target grid is now oriented. In figure 5-28, the target grid is oriented in the direction reported by the observer, 1,100 mils. If it is anticipated that a location may be used as the known point for future shift from a known point target location (for example, a registration point or a point recorded as a target), a north azimuth index should be constructed by use of the range-deflection protractor. Position and orient the target grid toward north as before. Instead of placing a pin opposite the 0, construct an index opposite 0. The index extends 1 inch above and 1 inch below the target grid (approximate range 2050 to 3300 on the RDP). Mark the index N as shown in figure 5-29.

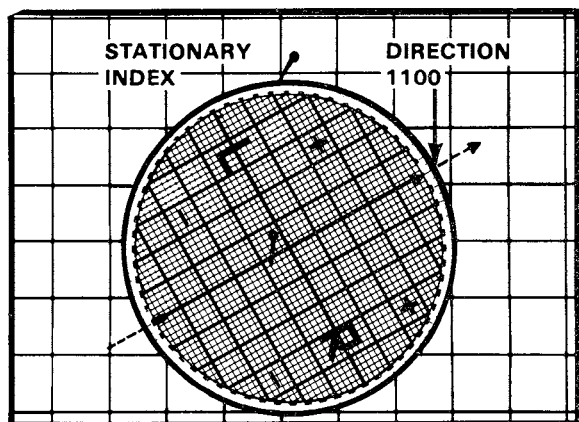


Figure 5-28. Locating the target by shift from a known point.

(2) Plot the shift given by the observer (left or right, add or drop) on the target grid. (Be sure to note the labeling of the target grid.) The pin will be in the target location.

EXAMPLE:

Observer reported (fig 5-28):

**SHIFT REGISTRATION POINT 1,
DIRECTION 1100, RIGHT 150,
DROP 400, OVER.**

(3) If the initial shift plots the point off the target grid, reposition the target grid so that both points fall on the target grid. Orient the target grid in the OT direction and plot the shift (fig 5-30).

(4) Recenter the target grid over the target location and orient it to the reported OT direction. This will permit the plotting of subsequent corrections and/or refinement. Once oriented, the target grid should be secured at all times by at least two pins to avoid unintentional movement.

EXAMPLE:

Observer reports:

**SHIFT REGISTRATION POINT 1,
DIRECTION 1100, LEFT 500,
DROP 2500, OVER.**

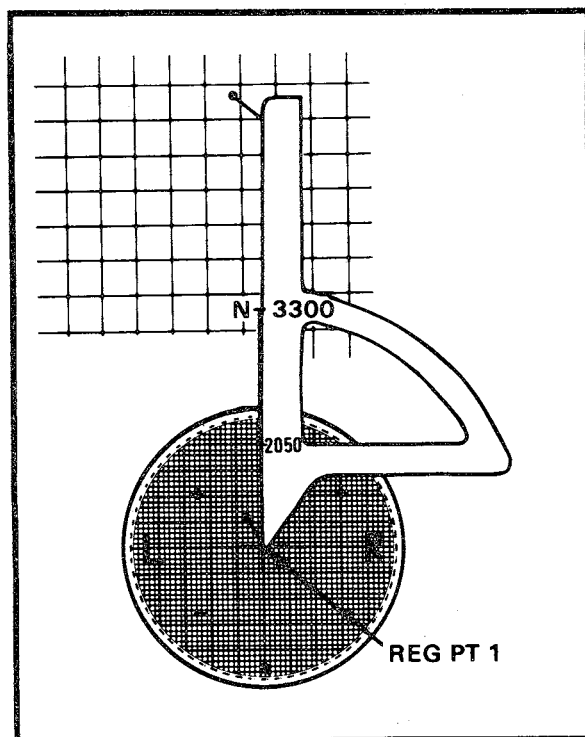


Figure 5-29. Construction of a north index.

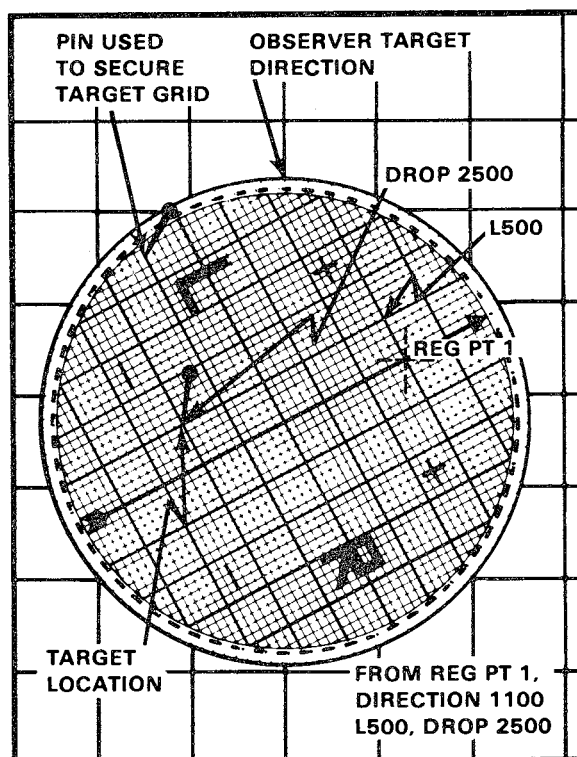


Figure 5-30. Locating the target when the initial shift plots off the target grid.

Section III

CHART DATA

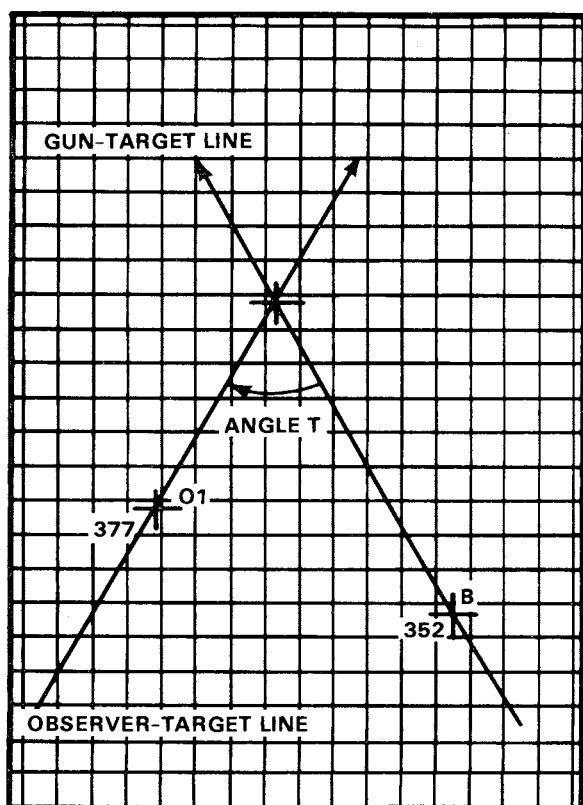


Figure 5-31. Angle T.

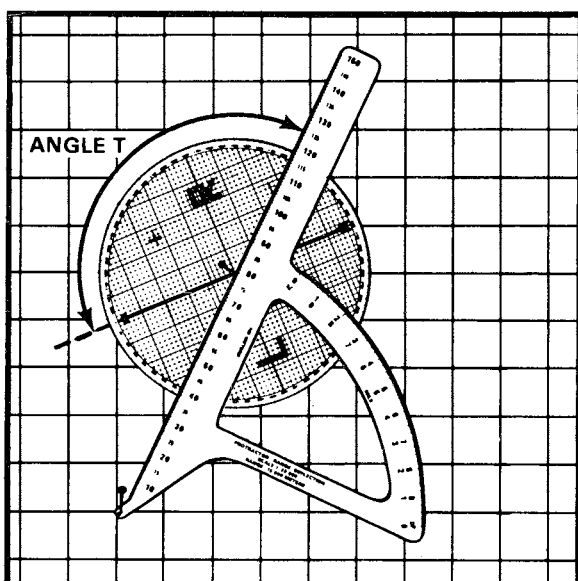


Figure 5-32. Determine angle T (head to head).

5-11. CHART RANGE AND CHART DEFLECTION

Chart range and deflection are measured as follows:

- a. Place the vertex of the RDP against the pin in the battery position, and place the left edge of the arm against the pin in the target location.
- b. Read the range, in meters, opposite the pin in the target location. Measure and announce the range to the nearest 10 meters.
- c. Read the chart deflection on the arc opposite the appropriate deflection index. To obtain the deflection, combine the 1,000-mil designation of the index with the reading on the arc. Announce the deflection to the nearest 1 mil.

5-12. ANGLE T

Angle T (fig 5-31) is the smaller interior angle formed at the target by the intersection of the GT and OT lines. It will therefore never be larger than 3,200 mils. After the initial chart range and deflection are announced, the target grid is oriented over the target location along the observer's direction. Angle T is then determined to an accuracy of 10 mils and announced by the chart operator. It is measured in the following manner:

- a. With the target grid centered on the target pin and oriented along the observer direction, place the vertex of the RDP at the firing unit location and place the left edge of the arm against the target pin. Either the 0 (head of the arrow) or 3200 (tail of the arrow) will be visible on the target grid to the left of the arm. Measure angle T either head-to-head or tail-to-tail. That is, if the 0 or head of the arrow is visible, determine the number of mils between the head of the arrow and the intersection of the arm of the RDP, with the target grid azimuth scale farther from the vertex (fig 5-32). If the 3200 or tail of the arrow is visible, determine the number of

mils between the tail of the arrow and the intersection of the arm of the RDP, with the target grid azimuth scale closer to the vertex (fig 5-33).

b. When the pin is not centered on the target grid and the FDO directs you to measure angle T, move the target grid so that the pin is centered and reorient the OT direction. Read angle T as described above.

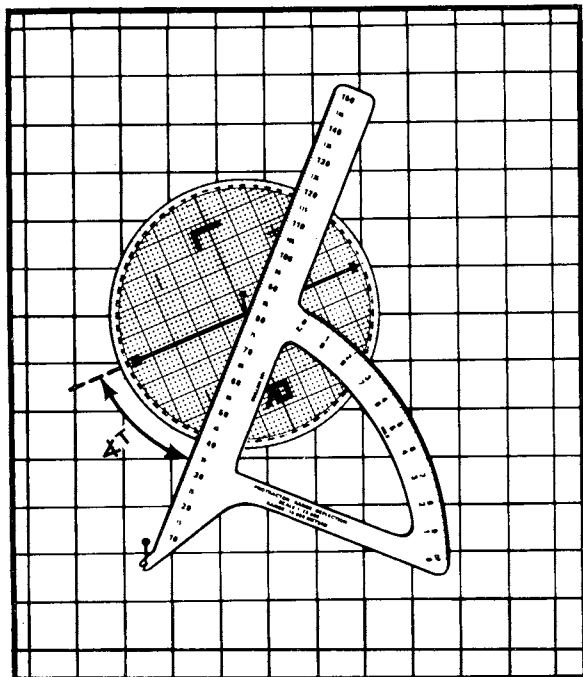


Figure 5-33 Determine angle T (tail to tail).

5-13. SUBSEQUENT CORRECTIONS

a. After the chart operator has determined chart range and deflection, he positions and orients the target grid as described in paragraph 5-11a. He then determines angle T. Subsequent observer corrections are plotted in the same manner as the shift from a known point. Corrections are visually interpolated to an accuracy of 10 meters on the target grid. After the observer's correction is plotted, a new chart range and deflection are determined. Angle T is not determined for subsequent corrections unless the observer requests it or changes his

direction, and thus causes angle T to become excessive (greater than 500 mils).

b. If the observer is not stationary, he should report a new OT direction if it changes more than 100 mils. To plot the new direction (and subsequent correction), center the target grid over the last pin location before reorienting for direction.

5-14. MANUAL-TO-COMPUTER OR CHART-TO-CHART CHECKS

a. One chart will differ slightly from any other because of small differences in construction caused by human limitations in reading the graphical equipment. Because of these differences, the following tolerances between charts are permissible:

Range/distance: ± 30 meters

Azimuth/deflection: ± 3 mils

b. To check the accuracy of two or more charts, plot the same grid intersection on all of the charts. Determine range and deflection to that point from the same firing unit location on all charts. All firing unit locations must be checked for accuracy. If all ranges agree within 30 meters and all deflections for the firing unit location agree within 3 mils, the checks are accurate for that firing unit location. If not, all charts must be checked for errors.

c. To ensure accuracy, sufficient points should be checked in the firing unit's zone of operations. For example, an error in plotting the unit location on one chart could compensate for an error in construction of the deflection index on the other chart. Checking at least two points will reveal the error. This should be done as a matter of unit standing operating procedure.

d. To perform chart verification with BCS, use center of battery (the average of all piece locations as displayed in the CORD field of the AFU;UPDATE) and store as an imaginary gun in BCS;PIECES. Center of battery corresponds to the battery location on the chart. Individual weapon locations are not plotted on the chart.

EXAMPLE:

Enter center of battery coordinates and altitude as gun 12 in BCS;PIECES format in an ON (Y) status.

FM;RFAF Enter grid intersection coordinates and altitude of target.

CORD: 68000/38000/361

PTF (adjusting piece to fire): 12

EXECUTE Gun orders displayed (DO NOT XMIT)

<i>FM;SUBS</i>	<i>Enter target number</i>	<i>TGT: AB0021</i>
	<i>Replot (rep)</i>	<i>REP: X</i>
	<i>Altitude</i>	<i>ALT: 361</i>

EXECUTE Displayed will be:

Replot range
Replot azimuth

GTRG: _____
GTAZ: _____

Use the GTRG and GTAZ to verify chart construction. When finished, change the status of the imaginary gun 12 to OFF (N) in BCS;PIECES. Accuracy tolerances are ± 30 meters range/distance and ± 3 mils deflection/direction.

e. To perform chart verification with the hand-held calculator, use the following

procedure: After battery setup in the HHC, enter the grid to the chart check location as a target. Use the battery altitude as the target altitude. Determine deflection/direction and range/distance from the HHC, and compare these data to the chart data to the same location. Accuracy tolerances are ± 30 meters range/distance and ± 3 mils deflection/direction.



CHAPTER 6

FIRE ORDER/FIRE COMMANDS/MESSAGE TO OBSERVER

There are three critical informational messages in the processing of a fire mission. The messages are the fire order, the fire commands, and the message to observer. In the fire order, the FDO tells the FDC how he has

decided to attack the target. The fire commands give all required information to the guns to begin, continue, and cease firing. The message to observer informs the observer of the FDO's decision on how to attack the target.

Section I FIRE ORDER

6-1. DEFINITION

When a request for fire is received at the FDC, the FDO must determine how the target will be attacked if the unit is operating in an autonomous mode. When operating with TACFIRE, the battalion FDO checks the plot on the digital plotter map and inspects the TACFIRE solution. If he concurs with the TACFIRE solution, he directs it to be transmitted to the appropriate fire units. If he disagrees with the TACFIRE solution, he makes modifications and then transmits the modified message to the units. The TACFIRE message is the fire order. In the autonomous mode or when the unit is equipped with the FADAC/manual system, the battery FDO must inspect the target plot on the situation map and conduct a brief analysis to determine how the target will be attacked. The result of his analysis is announced in the fire order. *A fire order is the fire direction officer's decision on how the target will be attacked.*

6-2. CONSIDERATIONS IN ATTACKING A TARGET

The FDO must consider several factors in determining how, if at all, to attack the target. At the battalion FDC, the TACFIRE will analyze the target based on the commander's criteria and then present a firing solution to the FDO. The TACFIRE technical firing solution will be for battery center to target center only. At the battery FDC working in an autonomous mode or in a battalion FDC without TACFIRE, the FDO must initially consider the following factors:

a. Location of Target. Check the location relative to friendly forces, fire coordination measures, zones of fire, and transfer limits. Range will affect the choice of fire unit(s) and the charge. Terrain may influence ammunition selection or the type of trajectory. High intermediate crests may require selection of a lower charge or use of high-angle fire.

b. Nature of Target. The size and type of target will affect the type and number of rounds to fire, any corrections for sheaf, and whether surprise is possible.

c. Ammunition Available. Consider the ammunition available and the controlled supply rate (CSR).

d. Fire Units Available. Consider the number of fire units available at the time of firing.

e. Commander's Guidance/Standing Operating Procedures. Operation orders, restrictions on ammunition, and SOPs may govern units and ammunition selected, target attack priority, method of attack, tactical mission, and desired percentage of casualties.

f. Request for Fire. Consider the observer's request, since he is observing the target and talking directly to the maneuver commander.

g. Munitions Effects. Consider the effects of munitions combinations as a guide to selecting the best munition to use in an attack.

h. Tactical Situation. Consider the counterfire threat.

6-3. FIRE ORDER ELEMENTS

In autonomous operations, the battery FDO must issue a fire order. This fire order will address any information needed to conduct the mission. If not covered by unit SOP, the following elements will be addressed (table 6-1):

a. Unit to Fire, Unit(s) to Follow the Mission, and Unit to Fire for Effect. Normally, BATTERY is announced as the unit to fire. If the fire order originates in the FADAC/manual battalion FDC and the FDO decides to fire the entire battalion, the element is announced as BATTALION. To designate less than the entire battalion to fire, ALFA AND CHARLIE, for example, may be announced. Unit call signs should be used when units to fire are being discussed outside the fire direction center.

b. Adjusting Element/Method of Fire of Adjusting Element (if Applicable). Normally, this will be the BCS-selected piece firing one round. In manual operation, the computer will select the adjusting piece.

c. Basis for Corrections. This element specifies how data will be determined. Normally, BCU is specified. Those units not equipped with it may designate FADAC, the graphical firing table, the hand-held calculator, the graphical firing table fan, or the fastest method.

d. Distribution. This is the pattern of bursts in the target area. The BCS will compute individual aiming points for each weapon on the basis of target description and layout in the battery area. If the FDO desires a different sheaf, he will announce it here. In a manual/FADAC fire direction center, the distribution will be accomplished according to BCU manual backup procedures or by massing platoons with platoon center to target center solutions.

e. Projectile. This is the projectile to be fired in fire for effect.

f. Ammunition Lot and Charge. These are the ammunition lots and charges used in adjustment and fire for effect.

g. Fuze. This is the fuze to be used in fire for effect.

h. Number of Rounds. This is the number of rounds to be fired in fire for effect by each howitzer.

i. Range Spread, Lateral Spread, Sweep and Zone, and High Angle. These are methods of attack used in special situations.

j. Time of Opening Fire. This is the time when the guns may commence firing. They may fire when ready, at my command (AMC), or time on target.

k. Target Number. Each mission will be assigned a target number, normally by TACFIRE, by BCS, or by the FDO if manual operations are being conducted.

Table 6-1. BCS defaults as fire order elements.

ELEMENTS	ADJUST FIRE, THEN FIRE FOR EFFECT	FIRE FOR EFFECT (NO ADJUSTMENT)
UNIT TO FIRE	BATTERY	BATTERY
ADJUSTING ELEMENT/ METHOD OF FIRE OF ADJUSTING ELEMENT	BCU SELECTS/①	FIRE FOR EFFECT
BASIS FOR CORRECTIONS	BCU	BCU
DISTRIBUTION	BCU SHEAF/DEFAULT CIRCULAR 100-METER TARGET RADIUS	BCU SHEAF/DEFAULT CIRCULAR 100-METER TARGET RADIUS
PROJECTILE	HE	DPICM
AMMUNITION LOT AND CHARGE	BCU SELECTS LOT AND CHARGE	BCU SELECTS LOT AND CHARGE
FUZE	POINT DETONATING	TIME
NUMBER OF ROUNDS	1, SHELL DPICM, BCU SELECTS LOT AND CHARGE, FUZE TIME	①
RANGE SPREAD, LATERAL SPREAD, ZONE OR SWEEP HIGH ANGLE		
TIME OF OPENING FIRE	WHEN READY	WHEN READY
TARGET NUMBER	NEXT AVAILABLE NUMBER	NEXT AVAILABLE NUMBER

6-4. ISSUING THE FIRE ORDER

a. TACFIRE. In TACFIRE operations, the battery FDO will execute the battalion-directed fire mission that is displayed on the BCS or announced by voice. The FDO should note the location and nature of the target on the situation map to ensure that the mission will not endanger friendly maneuver operations and to serve as one of the firing data double checks.

b. Battery Computer System. When operating with BCS in an autonomous mode, the battery FDO must compare the FM, RFAF displayed on the BCS with the known BCS defaults. The target must be plotted on the

situation map as a double check. The FDO will address any elements not covered by SOP that will change the BCS defaults. For example, the BCS will default to DPICM in the fire-for-effect phase of the mission. The FDO may not wish to expend DPICM and instead might announce high explosive (HE) as the fire-for-effect ammunition.

c. FADAC/Manual. In the FADAC/manual FDC, the FDO has the following additional considerations in issuing fire orders:

(1) Level of training of FDC personnel will affect the FDO's ability to establish SOP.

(2) Sequence of the fire order elements may facilitate timely processing of the mission.

d. The FDO must ensure that the fire order is clear and concise. The key to the fire order is that it is understood by all personnel in the fire direction center.

6-5. BATTALION FIRE ORDERS

a. *Battalion Fire Order Format.* In normal TACFIRE operations, the battalion fire order is transmitted to the fire units through TACFIRE message formats. The battalion FDO can agree with the TACFIRE solution or make appropriate changes. The approved message is sent to the fire units. In non-TACFIRE operations, the battalion sends voice fire orders. If a voice battalion fire order is required, the fire order elements previously discussed will be announced with the following modifications:

(1) A warning order is issued to indicate the type of mission (adjust fire [AF], FFE).

(2) In the unit to fire, the adjusting battery and batteries to fire in effect will be given. In adjust fire missions, the adjusting battery will follow the unit to fire (for example, **BATTALION, A**).

(3) The target location and altitude are announced.

b. *Control of Battalion Mass Missions.*

(1) Fire-for-effect mass missions on stationary targets can best be controlled by using time-on-target (TOT) techniques. The time on target may be announced as a specific time (for example, **TIME ON TARGET 0915**) or as a specific amount of time before it is to occur (for example, **TIME ON TARGET 5 MINUTES FROM...NOW**). The preferred method of use by BCS/TACFIRE is the specific time method.

(2) Fire-for-effect mass missions on moving targets or targets of a fleeting nature are best controlled by using **AT MY COMMAND** or **WHEN READY (WR)**. Time consumed in coordinating a TOT may result in rounds missing the target. Missions originated by use of the G/VLLD can be coordinated by using the target prediction method.

(3) Normally, the FFE phase of an adjust fire mission is controlled by announcing **WHEN READY**. It can be an **AMC** mission. Normally, time-on-target missions are not used, because the element of surprise is lost through adjustment.

6-6. BATTERY-LEVEL FIRE ORDERS

a. The driving force behind the fire order should be the fire order SOP established by the fire direction officer. An example of a fire order SOP is shown in table 6-2. This is the SOP used throughout the following discussion.

b. As discussed in paragraph 6-3, all elements of the fire order must be addressed either verbally or by the SOP.

(1) **Unit to fire.** Unless verbally changed, the unit to fire for effect will be the battery.

(2) **Adjusting element/method of fire of adjusting element.** The BCS will conduct an automatic selection routine to determine the adjusting piece for each mission. In any FDC that is a degradation of the TACFIRE/BCS fire direction center (no BCS or BCS down), the FDO may elect to use a similar process manually. For example, gun number 1 will adjust in mission 1 and gun number 2 will adjust in mission 2. The adjusting piece will normally fire one round, shell HE, fuze quick (Q) in adjustment.

(3) **Basis for corrections.** Normally, data are computed by use of the fastest method available in the fire direction center.

(4) **Distribution.** The FDO announces the sheaf to be used based on the call for fire (CFF) and target description. If the FDO agrees with the sheaf requested by the observer, no announcement by the FDO is necessary.

(5) **Projectile.** If the FDO decides to use the projectile that the observer requests, he does not have to verbally address this element. If the FDO decides to use a projectile other than the one requested, he must announce this in his fire order.

(6) Ammunition lot and charge.

The computer selects the projectile lot on the basis of the projectile specified by the FDO's fire order. The propellant lot and charge are determined based on the chart range and other tactical considerations.

(7) Fuze. If the FDO decides to use a fuze other than that requested by the observer, he must announce it in his fire order.

(8) Number of rounds. The FDO announces the number of rounds to be used in the fire-for-effect phase.

(9) Range spread, lateral spread, zone and sweep fire, high angle. These elements will be addressed if applicable.

(10) Time of opening fire. If other than when ready, the time of opening fire must be addressed by the FDO.

(11) Target number. The next available target number of the target block will be used unless a number has previously been assigned to the target.

***Note.** The FDO will use the same procedure as the observer in specifying the shell/fuze combination to be used for the mission. For example, when the FDO announces VT IN EFFECT, shell HE, fuze VT will be used.*

Table 6-2. Example of fire order standing operating procedures.

ELEMENT	CURRENT STANDARD
UNIT TO FIRE	BATTERY
ADJUSTING ELEMENT/METHOD OF FIRE OF ADJUSTING ELEMENT	NEXT PIECE/①
BASIS FOR CORRECTIONS	FASTEST METHOD
DISTRIBUTION	OBSERVER OR FDO WILL SELECT
PROJECTILE	OBSERVER OR FDO WILL SELECT
AMMUNITION LOT AND CHARGE	COMPUTER WILL SELECT
FUZE	OBSERVER OR FDO WILL SELECT
NUMBER OF ROUNDS	FDO WILL ANNOUNCE
RANGE SPREAD, LATERAL SPREAD, ZONE FIRE, OR SWEEP FIRE, HIGH ANGLE	NOT UNLESS SPECIFIED
TIME OF OPENING FIRE	WHEN READY
TARGET NUMBER	NEXT AVAILABLE NUMBER

Section II FIRE COMMANDS

6-7. DEFINITION

Fire commands are used by the FDC to give the cannon sections all information needed to start, conduct, and cease firing. They are sent to the section over the gun display units (GDU) in a battery operating with BCS or by voice in a battery without BCS. The initial fire commands include all elements

necessary for orienting, loading, and firing. Subsequent fire commands include only elements that are changed except quadrant elevation, which is always announced because it gives the howitzer section permission to fire. Fire commands are announced in sequence (table 6-3). Whether the battalion has GDUs or has voice only, the sequence of the fire commands is the same.

Table 6-3. Fire command elements.

SEQUENCE OF ELEMENTS	WHEN ANNOUNCED	
	INITIAL FIRE COMMAND	SUBSEQUENT FIRE COMMAND
1. WARNING ORDER	ALWAYS	NEVER
2. PIECES TO FOLLOW/ PIECES TO FIRE ¹ / METHOD OF FIRE	WHEN APPLICABLE WHEN OTHER THAN STANDARD	WHEN CHANGED WHEN CHANGED
3. SPECIAL INSTRUCTIONS DO NOT LOAD AT MY COMMAND HIGH ANGLE USE GUNNER'S QUADRANT AZIMUTH SPECIAL CORRECTIONS SWEEP/ZONE FIRE		
4. PROJECTILE ¹	WHEN NOT STANDARD	WHEN CHANGED
5. AMMUNITION LOT ¹	WHEN NOT STANDARD	WHEN CHANGED
6. CHARGE	ALWAYS	WHEN CHANGED
7. FUZE ¹ /FUZE SETTING ¹	WHEN NOT STANDARD	WHEN CHANGED
8. DEFLECTION	ALWAYS	WHEN CHANGED
9. QUADRANT ELEVATION	ALWAYS	ALWAYS
10. METHOD OF FIRE FOR EFFECT	WHEN APPLICABLE	WHEN CHANGED
¹ These elements may be designated as standard only if in the manual mode. Elements so designated will be announced only when something other than standard is to be fired.		

6-8. FIRE COMMAND ELEMENTS

a. Warning Order. A warning order is always announced to alert the firing battery to the mission. In a BCS battery, the warning order is a steady alarm signal from the case assembly of the GDU. The alarm indicates the start of the fire mission. When a firing battery is using voice commands, a warning order of **FIRE MISSION** will be announced.

b. Pieces to Follow/Pieces to Fire/Method of Fire. *Pieces to follow* indicates those elements that will follow the mission and fire when called upon. In a GDU-equipped battery, the do not load (DNL) indicator bars will be lit on the section chief assembly (SCA). This signifies that a particular piece is to follow the mission and prepare to fire when commanded. When using voice commands, the order **BATTERY ADJUST** is given. This indicates that all weapons will copy the commands, follow the mission, and eventually participate in the fire for effect. *Pieces to fire/method of fire* indicates the weapon(s) that will fire the initial data and how many rounds (rd) to fire. On the SCA of the piece to fire, the display will read 1 RD ADJ and the double indicator lights will be under the word **FIRE**. Voice commands will be **NUMBER 3, 1 ROUND**. This indicates that only that piece will fire one round. If more than one weapon or the entire battery is selected to fire, each weapon's SCA will have the **FIRE** indicator bars lit, and the display will indicate the number of rounds (for example, 02RD FFE). A voice command of **BATTERY, 2 ROUNDS** indicates that the entire battery will fire two rounds.

c. Special Instructions. Special instructions are used when actions are required that are different from normal. Within the BCS-equipped battery, restrictive commands (**DO NOT LOAD** or **AT MY COMMAND**) are signified by the double indicator bars under the DNL or AMC on the section chief assembly. Other special instructions of **HIGH ANGLE**, **GUNNER'S QUADRANT**, **AZIMUTH**, or **SWEEP/ZONE FIRE** will be specified as a digital readout in the display window of the SCA after the weapon's section chief presses the special instruction key. When using voice

commands, the FDC must announce the particular special instruction(s) to be used.

(1) **DO NOT LOAD** is a restrictive command that prohibits loading and firing. It is used within the BCS/GDU battery or in both the BCS/GDU and voice-commanded batteries when it is anticipated that significant time will elapse between loading and firing. Cancellation of this command is indicated by the double indicator bars being lit under the command **FIRE** in the display window of the section chief assembly. The voice command is **CANCEL DO NOT LOAD, QUADRANT (so much)**.

(2) **AT MY COMMAND** is a restrictive command that prohibits the battery from firing until directed to do so by the fire direction center. It is used during TOT missions to ensure that all rounds impact simultaneously. The guns fire when the alarm is heard and the double indicator bars are lit under the command **FIRE**. The voice command **FIRE** may also be used. Within the voice-commanded battery, **AT MY COMMAND** remains in effect until the command **CANCEL AT MY COMMAND** is given.

(3) **HIGH ANGLE** is displayed or announced to alert the crew that the mission is high angle.

(4) **USE GUNNER'S QUADRANT** is displayed or announced when the FDC desires that the gunner's quadrant (GQ) be used.

(5) **AZIMUTH** is displayed or announced to alert the guns to a large shift in direction of fire.

(6) **SWEEP/ZONE FIRE** is displayed or announced to alert the crew that the mission is a sweep/zone mission.

(7) **SPECIAL CORRECTION** is displayed automatically as an individual fire command to each firing piece in the BCS technical solution. It must be announced as part of the voice fire commands when a separate time, deflection, and/or quadrant is sent to one or more gun sections.

d. Projectile. The type of projectile that is to be prepared and loaded is always displayed in the section chief assembly. When voice fire commands are being used,

the projectile must be announced when it differs from standard.

e. Ammunition Lot. Ammunition lot numbers should be coded for simplicity. Separate-loading ammunition has two designators—the first letter for the projectile and the second letter for the propellant. Semifixed ammunition has only a one-letter designation. The lot designators are automatically displayed in the section chief assembly. When voice fire commands are being used, the lot designators must be announced when they differ from standard.

f. Charge. The amount of propellant to be used is displayed automatically in the section chief assembly. Charge must *always* be announced in initial voice fire commands. *It is not standardized.*

g. Fuze/Fuze Setting. When a projectile with a mechanical time (MT) or proximity fuze is fired, the computer determines a fuze setting that will cause the fuze to function at the desired point along the trajectory. The fuze/fuze setting is displayed automatically on the section chief assembly. Voice commands are announced as **FUZE TIME, TIME 17.6** or **FUZE VT, TIME 17.0**.

h. Deflection. Deflection to fire is always displayed in the SCA as a four-digit deflection. In voice commands, deflection is always announced as four digits; for example, **DEFLECTION 3245**.

i. Quadrant Elevation. The quadrant elevation is displayed/announced in the initial and all subsequent fire commands. The displayed/announced command (for example, **QUADRANT 309**) is permission for the chief of section to load and fire the round unless otherwise restricted by special instructions.

j. Method of Fire For Effect. The method of fire for effect indicates the number of rounds and types of ammunition to be used in effect. This is displayed automatically in the SCA. The method of fire for effect will be announced by voice command after quadrant elevation (for example, **2 ROUNDS, FUZE VT IN EFFECT**). This command allows the nonadjusting elements to prepare the ammunition for the fire-for-effect phase of the mission.

k. Special Methods of Fire. Special methods of fire include **CONTINUOUS FIRE** and **FIRE AT WILL**. These are voice commands only and cannot be displayed on the section chief assembly. However, sweep and/or zone fires, which are special methods of fire, can be displayed on the SCA and can be announced in voice commands.

6-9. STANDING OPERATING PROCEDURES

If no restriction has been imposed, unit SOP may allow loading when deflection is announced. This is discouraged for self-propelled weapons, because the noise of the rammer may keep the voice-announced quadrant from being heard. Fire commands for special missions such as coordinated illumination should be addressed by unit SOP according to the unit's level of training.

6-10. OTHER FIRE COMMANDS

a. Check Firing. The command **CHECK FIRING** can be given by anyone and will cause firing to cease immediately. This command will be used when all data have been sent to the guns and an item must be changed. The SCA displays **CHECK FIRE**.

b. Cease Loading. The command **CEASE LOADING** allows the firing battery to fire rounds that are loaded, but no additional rounds may be loaded. It is a voice command only, except in final protective fire (FPF) missions with the BCS.

c. End of Mission. The command **END OF MISSION (EOM)** means that the fire mission is terminated. The guns should return to the azimuth of lay (or priority target data). The SCA displays **EOM**.

d. Planned Targets. The battery may be assigned planned targets for which current firing data must be maintained. The FDC may designate targets as priority targets for the battery or for each platoon.

Each target is assigned a number, and each weapon is laid on its assigned priority target. In such cases, unit SOP usually designates a command or prearranged signal to fire on the priority target, bypassing the usual sequence of fire commands. Assume target AC7343 has been planned. On the command **RIGHT, SUPPRESS AC7343**, the right platoon engages target AC7343 with the previously arranged method of fire. In defensive operations, the command **FIRE THE FINAL PROTECTIVE FIRES** causes the firing battery to fire the final protective fires on which it is laid.

6-11. REPORTS

The section chief reports to the FDC all actions that affect the firing of his weapons in support of the battery mission. During firing, the following specific reports are made in a voice operation:

a. **SHOT NUMBER (so-and-so)** after each round has been fired.

b. **ROUNDS COMPLETE NUMBER (so-and-so)** when the final round has been fired in effect.

c. **MISFIRE NUMBER (so-and-so)** when there has been a misfire.

d. Number of rounds expended by type and lot number when requested by the FDC (voice only or per SOP).

e. Errors if any round has been fired with improper data. The section chief reports to the FDC the actual data fired in error; for example, **NUMBER 2 FIRED DEFLECTION (so much)**.

6-12. REPETITION AND CORRECTION OF FIRE COMMANDS

a. One section of the firing battery should be designated to read back all voice fire commands to ensure that the howitzer sections have received the fire commands correctly. When a command has not been heard or is misunderstood, the request for repetition is stated as a question; for example, **DEFLECTION NUMBER 3?** When the FDC replies, the repetition of commands is always preceded by **NUMBER (so-and-so), THE COMMAND WAS** (for example, **NUMBER 3, THE COMMAND WAS DEFLECTION 2768**).

b. If an incorrect command has been given but the command **QUADRANT** has not been announced, the FDC commands **CORRECTION** followed by the correct command and all subsequent elements. If **QUADRANT** has been announced, the FDC commands **CHECK FIRING. CANCEL CHECK FIRING** is announced followed by the corrected element and all subsequent elements.

Section III MESSAGE TO OBSERVER

6-13. DEFINITION

After the manually equipped battery FDC receives the call for fire, the FDC analyzes the target. If he decides to fire the target with artillery assets, he issues the fire order as his decision. That decision is announced to the observer in the form of a message to observer. The message to observer consists of four items and is composed by the radiotelephone operator or is sent automatically by the battery computer system.

a. **Units to Fire**—the battery or batteries that will fire the mission. The units are identified by their radio call signs to the extent that they can be identified by the observer. If a battalion is firing in effect with one battery adjusting, the message to observer designates the fire-for-effect unit (battalion) and the adjusting unit (battery).

b. **Changes to the Call for Fire**—changes the observer needs to be informed of that have been made to his request for fire by

the fire direction officer. That information is passed to the observer in the second element of the message to observer. For example, the observer requests VT in effect, and the FDO decides to fire DPICM in effect. The RATELO announces **T6H32, DPICM IN EFFECT**.

c. Number of Rounds—the number of volleys in fire for effect. For example, the FDO decides to fire five rounds in effect. He announces **T6H32, DPICM IN EFFECT, 5 ROUNDS**.

d. Target Number—the number assigned to the mission for reference purposes. For example, the next target number is AD3476. The FDO announces **T6H32, DPICM IN EFFECT, 5 ROUNDS, TARGET NUMBER AD3476**.

6-14. ADDITIONAL INFORMATION

a. Additional information may be transmitted with or following the message to observer.

(1) If the probable error in range for an area mission is greater than or equal to 38 meters, the FDC will inform the observer. If the probable error in range for a registration is greater than 25 meters, the FDC will inform the observer.

(2) Angle T is sent to the observer when it is greater than or equal to 500 mils or when it is requested by the observer. Angle T is announced to the observer to the nearest 100 mils. For example, angle T is 580 mils. It is announced as **ANGLE T 600**.

(3) The pulse repetition frequency for a Copperhead mission is sent when applicable; for example, **PRF CODE 241**.

(4) Time of flight is announced to the nearest second. It is announced to observers when targets are being engaged with shell Copperhead, when moving targets are being engaged, or when time of flight is requested; for example, **TIME OF FLIGHT 47**. *Time of flight is always announced to an air observer.*

(5) If high angle is used, it is included in the message to observer if the observer did not request it.

(6) **SPLASH** may be sent at observer's request (mandatory for air observers and high-angle missions).

b. The BCU automatically generates a standard format message to observer. This message to observer contains many items that allow the receiving digital message device (DMD) to establish a mission file. See the operator's manual or the job aids for a discussion.

c. The messages to observer for registrations are in the following format:

(1) The precision registration message to observer is initiated in the FDC. It tells the observer to register at a specific point (known point or encoded coordinates) and gives fuzes (point detonating [PD] and/or time) and the probable error in range if it is greater than 25 meters; for example, **C8T16, THIS IS D2B23, REGISTER ON REGISTRATION POINT 1, QUICK AND TIME, OVER**. The observer will report his direction to the FDC when he is ready to observe.

(2) The high-burst (HB)/MPI registration message to observer is sent to the observer(s) who will participate. It is composed in the following format:

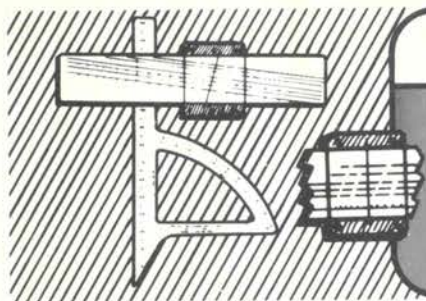
(a) A warning order alerts the observers to prepare to observe a certain type of registration; for example, **T2H13, T2H37, THIS IS B6H16, OBSERVE HIGH-BURST REGISTRATION**.

(b) Orienting data to the orienting point (direction and vertical angle) for observer O1 are sent; for example, **O1 DIRECTION 0510, VERTICAL ANGLE +16**.

(c) O1 (or the single G/VLLD-equipped observer) is directed to measure the vertical angle; for example, **MEASURE THE VERTICAL ANGLE**.

(d) Observer O2 (when applicable) is oriented to the orienting point; for example, **O2 DIRECTION 6130, VERTICAL ANGLE +6**.

(e) The observers are directed to report when they are ready to observe; for example, **REPORT WHEN READY TO OBSERVE**.



CHAPTER 7

FIRING TABLES

Field artillery firing data are determined by use of firing tables. These firing tables contain the fire control information (FCI) for firing under standard conditions and data for correcting for nonstandard conditions. The three types of firing tables are the tabular firing tables, the graphical firing tables/graphical firing table fans, and the graphical site tables. The TFT is the base document. It contains fire control information in a tabular format. The FCI is based on test firings and computer simulations of the ammunition listed. The data listed are corrected to standard conditions. The GFT/GFT fan and the GST are graphical

representations of tabular firing tables. They expedite the computation of firing data.

The Armies of the United States, United Kingdom, and Australia and the Canadian Forces (ABCA) agree to use standard tabular firing tables for the manual preparation of firing data. This agreement is known as QSTAG 220.

The Armies of the United States and her NATO allies agree to adopt the standard firing tables format for NATO artillery cannons for the manual preparation of firing data. This agreement is known as STANAG 4119.

Section I

GRAPHICAL FIRING TABLES

7-1. MEANS OF DETERMINING FIRING DATA

The GFT is developed from data in the tabular firing tables. It is used as an expedient method of interpolating data from the tabular firing tables. Graphical firing tables are prepared for each weapon for most shell families.

7-2. DESCRIPTION AND USE OF THE LOW-ANGLE GFT

Each GFT is printed on a rule that has a cursor with an engraved fine hairline. The

cursor serves as the index for reading data. The hairline is perpendicular to the scales. It is known as the manufacturer's hairline (MHL). The rule described in this section is the HOW 155mm 155AM2HEM107 CHARGE 4GB (fig 7-1).

a. Scales on the Low-Angle GFT. The scales on each rule are drawn at a slant to the base, angling from upper left to lower right. The scales appearing on the rule, from top to bottom, are as follows:

(1) **Improved conventional munitions scale.** An improved conventional munitions (ICM) scale is on some graphical firing tables. It is located above the DEFL CORR/DRIFT scale. It consists of a QE scale

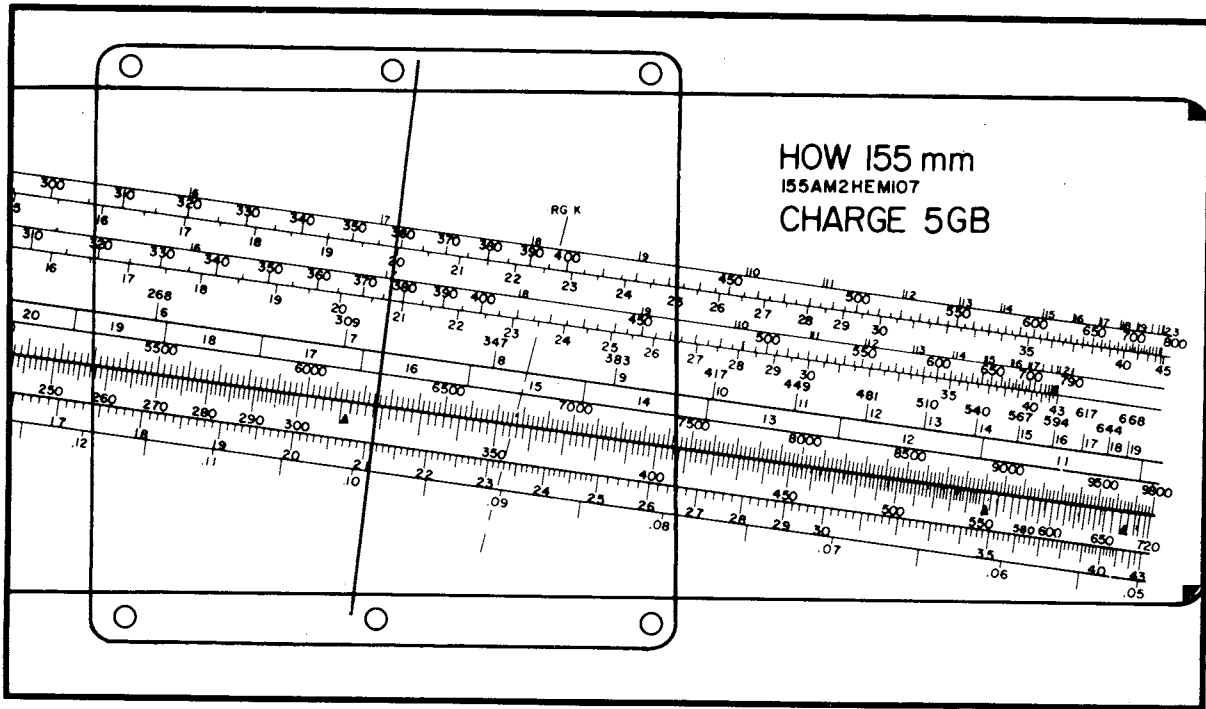


Figure 7-1. Low-angle graphical firing table.

and a fuze setting (FS) scale. The QE scale is graduated in mils, and the fuze setting scale is graduated in fuze setting increments. The ICM scale applies to a specific type of ICM. It has the model number at the left end of the scale.

(2) **Drift scale.** The drift scale gives the projectile drift correction (corr) in mils. This correction is always made to the left, since the projectile drifts to the right. Each HE elevation (el) at which drift changes (becomes 0.5 mil between the values) is printed in red. Artillery expression is applied to determine the value of drift at that elevation. For example, at elevation 362, the drift is actually 7.5, so it is applied as L8.

(3) **100/R scale.** The 100/R scale gives the number of mils necessary to move the burst laterally or vertically 100 meters at the given range. These numbers are printed in red. The scale is based on the mil relation formula ($m = W/R$).

(4) **Range scale.** The range scale is the base scale, and all other scales are based on it. Range is expressed logarithmically in meters. The scale varies for each charge. The range scale is developed to give as large a

range spread as possible and still permit graduations large enough to be read accurately. Range is read to the nearest 10 meters.

(5) **Elevation scale.** The elevation scale is graduated in mils and is read to the nearest 1 mil. The numbers on this scale are printed in red and black. The red numbers denote the elevations that are within range transfer limits for a one-plot GFT setting.

(6) **Fuze setting scale.** The fuze setting scale gives the fuze settings for time fuze M564 and is used for the time fuze M582 without modification. The values are read to the nearest 0.1 fuze setting increment. The fuze setting scale is also used to determine time of flight and VT fuze settings.

(7) **Δ FS/ Δ 10M height-of-burst scale.** The change to fuze setting that is necessary for a 10-meter change in the height of burst (HOB) is found on the Δ FS/ Δ 10M HOB scale. This scale is read to the nearest 0.01 fuze setting increment. It indicates the amount of correction that must be applied to the M564 or M582 time fuze setting to raise or lower the height of burst 10 meters along the trajectory.

Note. On GFTs produced before 1983, a fork scale is drawn. The fork scale is not used.

(8) **Met check gage points.** Above the fuze setting line, there are red triangular gage points. The apex of each triangle points to the quadrant elevation that, under standard conditions, results in the maximum ordinate of the trajectory passing through a whole line number of a met message. The range and quadrant elevation at the met check gage point are preferred for registration aiming points, for met + VE computations, and for determination of GFT settings.

(9) **Height-of-burst probable error gage points.** Height-of-burst probable error gage points are found on some GFTs above the fork scale or on the FS scale. They are red right triangles. These gage points indicate the range and fuze settings at which the probable error in height of burst is 15 meters. Larger height-of-burst dispersion must be expected when a time fuze is used with a particular charge at a range exceeding the gage point. Some charges have two such gage points. The one on the left indicates the range at which the probable error in height of burst for the next lower charge is 15 meters.

(10) **Range probable error gage point.** Above the Δ FS/ Δ 10M HOB scale, there is a black equilateral triangle. This gage point indicates the range at which the range probable error equals 25 meters. For all ranges to the right of the gage point, range probable error exceeds 25 meters.

(11) **Range K line.** The range K line is a broken black line near the right edge of the rule. The angle that the range K line makes with the scales geometrically portrays the predicted rate at which range K varies with range. An elevation gage line drawn parallel to the range K line for a one-plot GFT setting provides elevation settings that vary at the same rate as does range K. The range K line is ignored for multiplot GFT settings.

(12) **Fuze K line.** The fuze K line is a broken black line near the left edge of the rule. The angle that the fuze K line makes with the scales geometrically portrays the predicted

rate at which fuze K varies with range. A time gage line drawn parallel to the fuze K line for a one-plot GFT setting provides few settings that vary at the same rate as does fuze K. The fuze K line is ignored for multiplot GFT settings.

b. Firing Data (No GFT Setting).

The procedure for determining the elevation and fuze setting with the conventional GFT when no corrections (no GFT setting) are known is as follows:

(1) Place the MHL over the announced chart range.

(2) Read the elevation under the MHL from the elevation scale.

(3) Read the fuze setting (M564 or M582) under the MHL from the fuze setting scale.

(4) Determine the VT fuze setting by reading the time on the fuze setting scale corresponding to the elevation to be fired. Always express variable time as a whole value. Consequently, if the value read from the time scale is not a whole value, drop the tenths and express the value to the next lower whole value (for example, express 17.8 as 17.0).

7-3. CONSTRUCTION OF GFT SETTINGS

a. The GFT setting is used to apply corrections for nonstandard conditions. The corrections are determined by firing, determined by met + VE, or inferred from the computer. The preferred GFT setting is the multiplot (the one with three or more sets of corrections) (fig 7-2). The alternate one-plot GFT setting should be used only if the unit does not have access to a computer or has not fired several registrations with the same charge. The elements of each GFT setting are always expressed and recorded in the following sequence:

(1) Unit for which the GFT setting is prepared (for example, GFT A).

(2) Charge (for example, Chg 5).

(3) Ammunition lot (for example, Lot XY).

(4) GFT setting range (chart range or achieved range used in computing the GFT setting) (for example, Rg 4860).

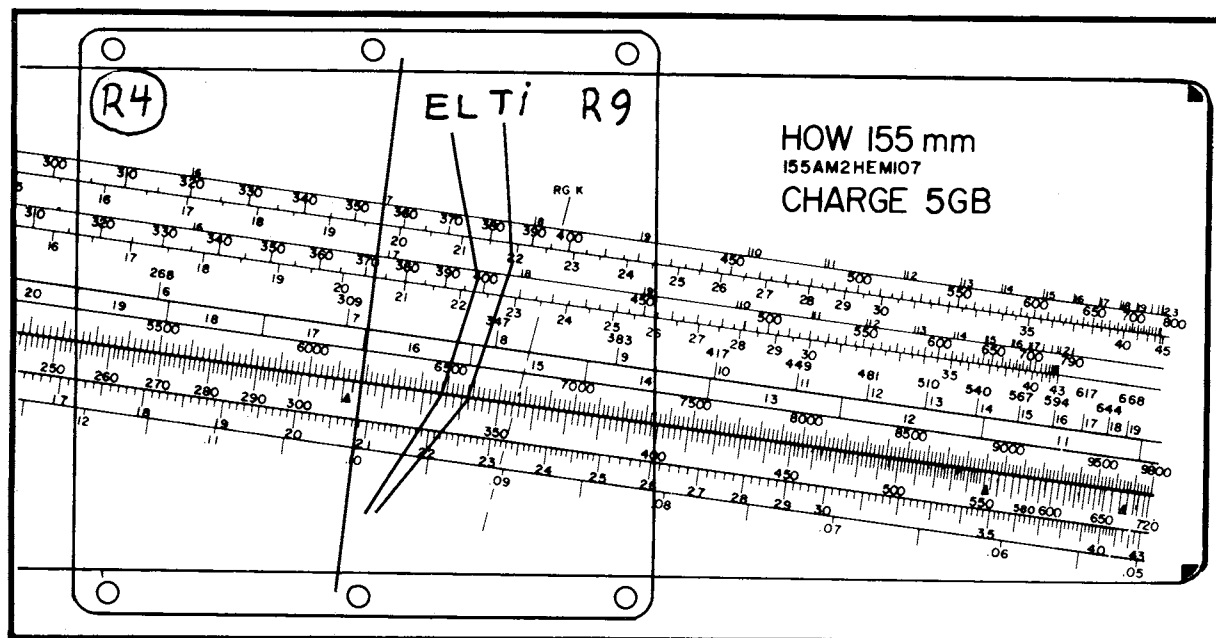


Figure 7-2. Multiplot graphical firing table setting.

(5) Adjusted elevation (for example, El 222).

(6) Adjusted time (for example, Ti 14.6).

(7) Deflection correction (for example, Total [Tot] Df Corr: L8; GFT Df Corr: L3).

b. There are no range limits for a multiplot GFT setting. To apply a multiplot GFT setting (preferred), use the following procedures (fig 7-2):

(1) Slide the cursor until the MHL is exactly over the GFT range on the range scale.

(2) Using a soft-lead pencil, place a dot on the cursor at the adjusted elevation along the elevation scale.

(3) Place a second dot on the cursor at the adjusted time along the M564 fuze setting scale.

(4) Repeat these steps for all sets of corrections until all the data have been recorded.

(5) Using a straightedge and a soft-lead pencil, connect all the elevation dots, and label the line segment EL. Connect the time dots, and label the line segment TI.

(6) Check the GFT setting by sliding the cursor back to the ranges for the sets of

corrections, and read the data plotted for each range.

(7) Take the average of the total deflection corrections, and record it on the upper left portion of the cursor and draw a circle around it. Take the average of the GFT deflection corrections, and record it on the upper right portion of the cursor.

c. To apply a one-plot GFT setting (fig 7-3), use procedures in *b*(1) through (3) above and slide the elevation dot over the RG K line. Trace the line and label it EL. Also, slide the cursor until the time dot is over the FZ K line. Trace the fuze K line and label it TI. Slide the cursor back over the GFT range, and read the original set of data. Apply the total deflection correction on the upper left portion of the cursor and draw a circle around it. Record the value of the GFT deflection correction on the upper right portion of the cursor.

7-4. DETERMINATION OF FIRING DATA BY USE OF THE GFT SETTING

a. Reading the GFT Scales.

(1) **Improved conventional munitions scale.** Slide the cursor until the MHL

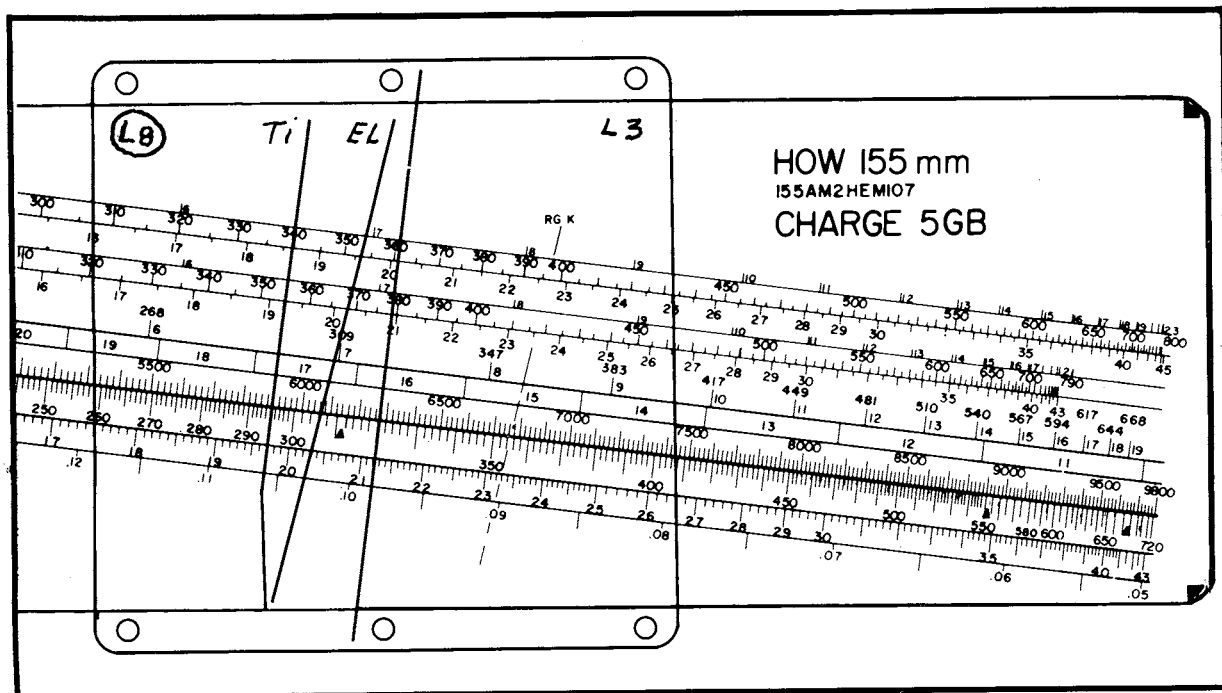


Figure 7-3. One-plot graphical firing table setting.

is over the HE (or base projectile) quadrant elevation on the elevation scale. Read the ICM QE under the MHL on the ICM scale. To determine the ICM fuze setting, place the MHL over the M564/M582 fuze setting and read the ICM time under the MHL on the ICM fuze setting scale. See chapter 9, section I, for instructions on the use of this scale.

(2) **Drift scale.** Move the cursor until the MHL is over the range. Read drift under an imaginary line that is parallel to the MHL and crosses the elevation gage line at the elevation scale. Drift can also be read by placing the MHL over the elevation determined and reading the value of drift under the MHL. Drift is a function of elevation but cannot be read directly under the elevation gage line.

(3) **100/R scale.** 100/R is a function of range and is read under the manufacturer's hairline. Since it is based on the mil relation, 100/R is unaffected by corrections for nonstandard conditions, charge, projectile, or caliber.

(4) **Range scale.** Slide the cursor until the MHL is over the range on the range scale. The range scale is the base scale of the graphical firing table.

(5) **Elevation scale.** Slide the cursor until the MHL is over the range on the range scale. Read the elevation under the elevation gage line where it crosses the elevation scale.

(6) **Fuze setting scale.** Read the time to be set on the M564/M582 fuze under the TI gage line where it crosses the fuze setting scale.

(7) **Fork scale.** Not used.

(8) **Δ FS/ Δ 10M HOB scale.** Δ FS is a function of fuze setting but cannot be read under the time gage line. It is read on the Δ FS/ Δ 10M HOB scale under an imaginary line that is parallel to the MHL and crosses the fuze setting scale at the same point as the time gage line. It can also be determined by placing the MHL over the fuze setting determined and reading Δ FS/ Δ 10M HOB under the manufacturer's hairline.

(9) **Variable time fuze setting or time of flight.** Variable time fuze setting or time of flight is a function of elevation but cannot be read under the elevation gage line. Read it on the M564/M582 fuze setting scale under an imaginary line that is parallel to the MHL and crosses the elevation scale at the same point as the elevation gage line. After reading

a value from the M564/M582 fuze setting scale, determine the VT fuze setting by dropping the tenths of a fuze setting increment. Also determine the VT fuze setting by moving the MHL to the elevation determined, reading the fuze setting from the FS scale, and dropping the tenths of a fuze setting increment.

b. Reading the GFT Settings. Figure 7-4 graphically displays the correct procedure for reading firing data from the graphical firing table.

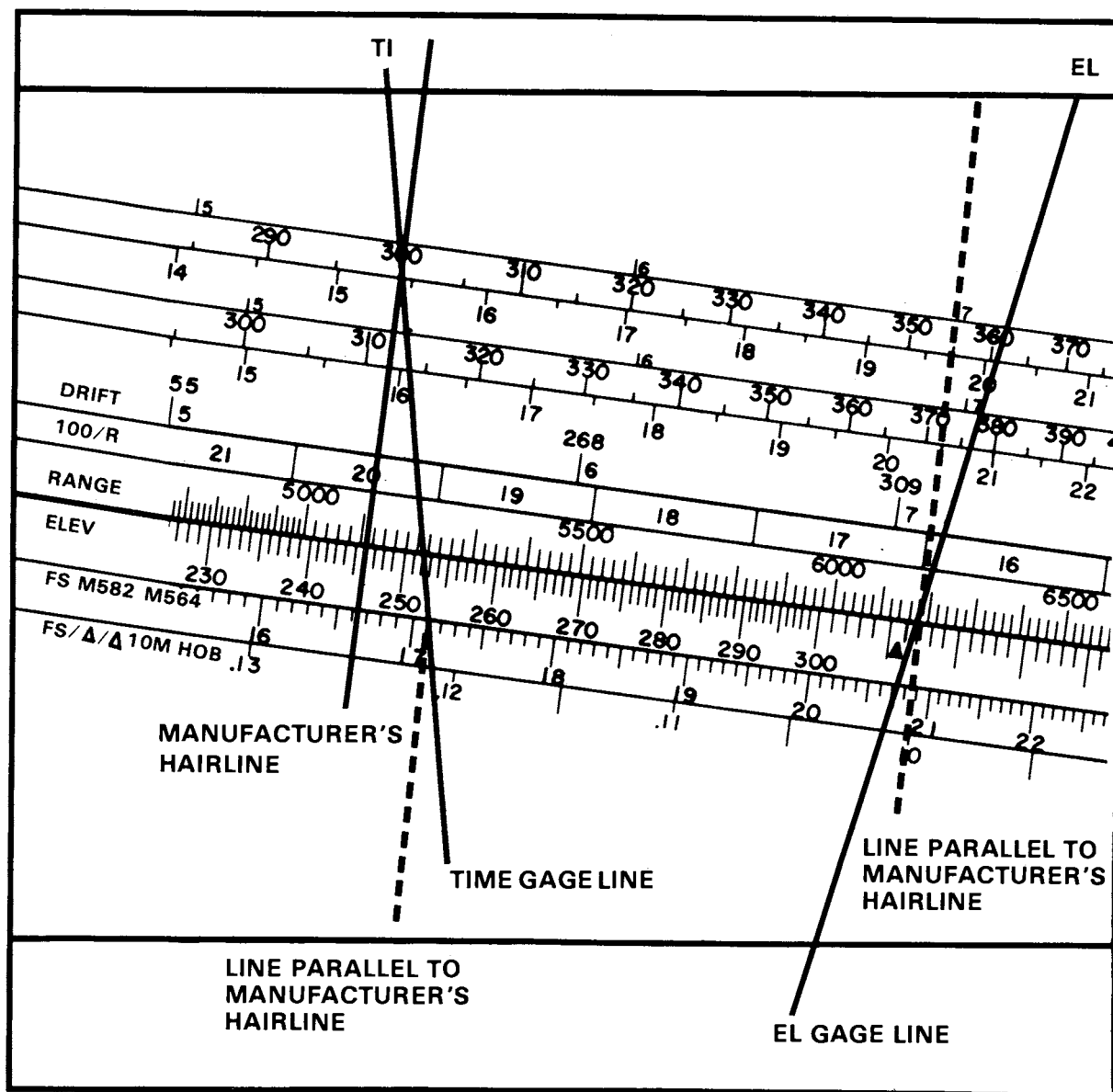


Figure 7-4. Reading graphical firing table.

Section II

GRAPHICAL FIRING TABLE FAN

7-5. DESCRIPTION

The GFT fan is a range-deflection protractor modified to hold a ballistic template over the arm (fig 7-5). The ballistic template has a series of scales for each charge. Only the best ranges for each charge are listed on the GFT fan. Once a target is plotted on the firing chart, the chart operator can determine and announce firing data to the target for a center-of-battery to center-of-target solution.

a. Range Scale. The range scale is the base scale of the GFT fan. It runs along the left edge of the ballistic template and corresponds to the ranges etched on the range-deflection protractor. It is graduated in the same manner as the range-deflection protractor. Range can be read to an accuracy of 10 meters under the MHL on the cursor.

b. Charge. The GFT fan may list several charges that could be fired at the chart range. The charge selected to fire should have at least 500 meters over and short in range to allow for observer adjustment.

c. Elevation Scale. Along the right edge of each charge ballistic scale is the elevation scale. It is graduated every 5 mils and labeled every 50 mils. Elevation is visually interpolated to the nearest 1 mil.

d. Fuze Setting Scale (M564). Along the left edge of each charge ballistic scale is the M564 time fuze setting scale. This scale is graduated every whole fuze setting increment and labeled every 5 whole fuze setting increments. Fuze setting is visually interpolated to the nearest 0.1 fuze setting increment.

e. Drift Scale. The drift scale is to the right of the charge elevation scale. It is read in the same manner as the drift scale on the graphical firing table.

f. 100/R Scale. The 100/R scale is along the right edge of the ballistic template. It is read in the same manner as the 100/R scale on the graphical firing table.

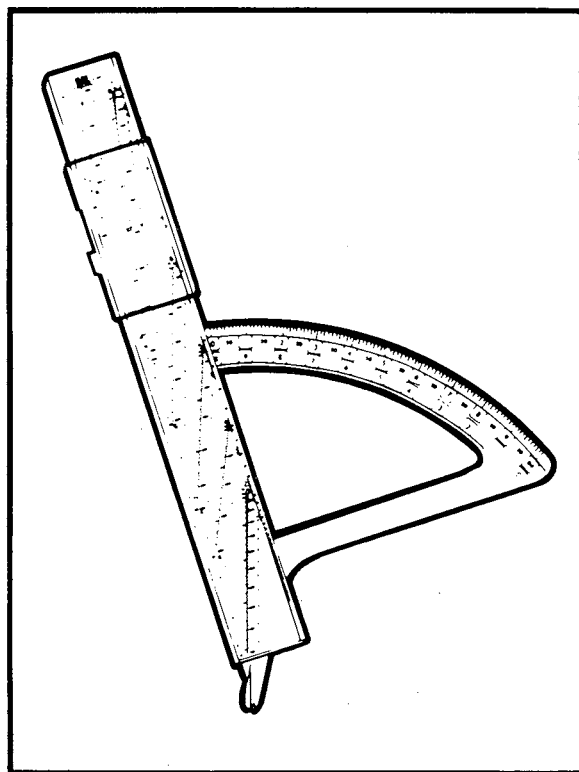


Figure 7-5. Graphical firing table fan.

g. $\Delta FS / \Delta 10M$ HOB Scale. This scale is not found on the GFT fan. Use the TFT or GFT to determine this value.

7-6. CONSTRUCTION OF A GFT SETTING ON A GFT FAN

Use a multiplot GFT setting if available. The procedure for applying a multiplot GFT setting is the same as that described in paragraph 7-3b. If only one plot is available, construct the GFT setting on the GFT fan by use of the following procedure:

GFT A: Chg 4, Lot XY, Rg 5000, El 316, Ti 19.3; GFT Df Corr: L2, Tot Df Corr: L8.

a. Construct the GFT setting on the graphical firing table.

Note. If several cursors are available (NSN 5355-01-076-5554), place only one GFT setting per charge on each cursor.

b. Slide the cursor of the GFT fan until the MHL is over the range of 5,000 meters on the range scale.

c. Using a soft-lead pencil, place a dot on the cursor of the GFT over elevation 316 of the charge 4 elevation scale.

d. Place a second dot on the cursor at the GFT time of 19.3 along the charge 4 M564 fuze setting scale.

e. On the charge 4 GFT, slide the cursor until the MHL is over met check gage point range 3730 (a met check gage point representing the same line number used in the registration). Read the corresponding elevation (221) under the elevation gage line and the fuze setting (13.7) under the time gage line.

f. Slide the cursor of the GFT fan until the met check gage point range 3730 is under the manufacturer's hairline. Place dots corresponding to the met check gage point EL and TI as above.

g. The GFT fan cursor now has four dots on it. It has two elevation dots and two fuze setting dots. With a straightedge, draw a line through the elevation dots. Do the same with the fuze setting dots. These lines represent the elevation and time gage lines and are parallel to the RG K and FZ K lines of the graphical firing table. Label these lines EL and TI respectively.

h. Place the GFT deflection correction on the upper right-hand corner of the cursor.

Place the total deflection correction on the upper left-hand corner of the cursor.

7-7. DETERMINATION OF FIRING DATA WITH THE GFT FAN

The GFT fan can be used by the chart operator to determine all manual firing data.

a. Charge. Once the target is plotted and the fan aligned with it, the operator can announce the optimum charge for the mission.

b. Fuze Setting. If a time or proximity fuze is designated in the fire order, the fuze setting is determined and announced.

c. Deflection. Two brief mental computations are required of the operator to determine deflection.

(1) First, the operator must determine the deflection correction by applying the GFT deflection correction (average) to drift.

(2) Then, the operator must apply this correction to the chart deflection to get the deflection to fire.

d. Site. The VCO determines site.

e. Quadrant Elevation. The operator reads elevation from the GFT fan and applies site. He then announces quadrant elevation. The site used may be an average site or one computed with the graphical site table.

f. 20/R. If an airburst is required, 20/R must be determined and applied to the quadrant elevation. When M728 fuzes are fired, 20/R is not applied.

Section III TABULAR FIRING TABLES

7-8. STANDARDS

Tabular firing tables are based on the test firing and computer simulations of a weapon

and its ammunition correlated to a set of conditions that is defined and accepted as standard. These standards are points of departure. Corrections are used to

compensate for variables in the weather/weapon/ammunition combination that are known to exist at a given instant and location. The atmospheric standards accepted in US firing tables reflect the mean annual condition in the North Temperate Zone.

7-9. ELEMENTS AND PURPOSE OF THE TFT

a. The principal elements measured in experimental firings include angle of elevation, angle of departure, muzzle velocity, achieved range, drift, and current atmospheric conditions.

b. The main purpose of a TFT is to provide the data to bring effective fire on a target under any set of conditions. Data for firing tables are obtained from firings conducted with a weapon at various quadrant elevations. Computed trajectories based on the equation of motion are compared with the data obtained in the firings. The computed trajectories are then adjusted to the measured results and data are tabulated. Data for elevations not fired are determined by interpolation. Firing table data define the performance of a projectile of known properties under conditions of standard muzzle velocity, standard weather, and a motionless earth. The introduction of each TFT describes its contents and use.

Section IV GRAPHICAL SITE TABLES

7-10. DESCRIPTION

a. Advantages of the GST. The GST was developed to provide a quick, accurate computation of vertical angle, angle of site, and site. The GST can also be used to compute VI when the site, charge, and range are known; when the angle of site and range are known; or when the vertical angle and distance are known. The GST includes a means for converting yards to meters or meters to yards without any additional

movement of the slide or cursor. Each GST is designed for a particular weapon, and site computations are valid only for the weapon specified on the graphical site table. When angle of site is greater than ± 100 mils, the GST cannot be used to compute site.

b. Components of the GST. The GST described in this section is GST HOW 155 mm, FT 155-AM-2, PROJ HEM107. The GST consists of a base, a slide, and a cursor (fig 7-6).

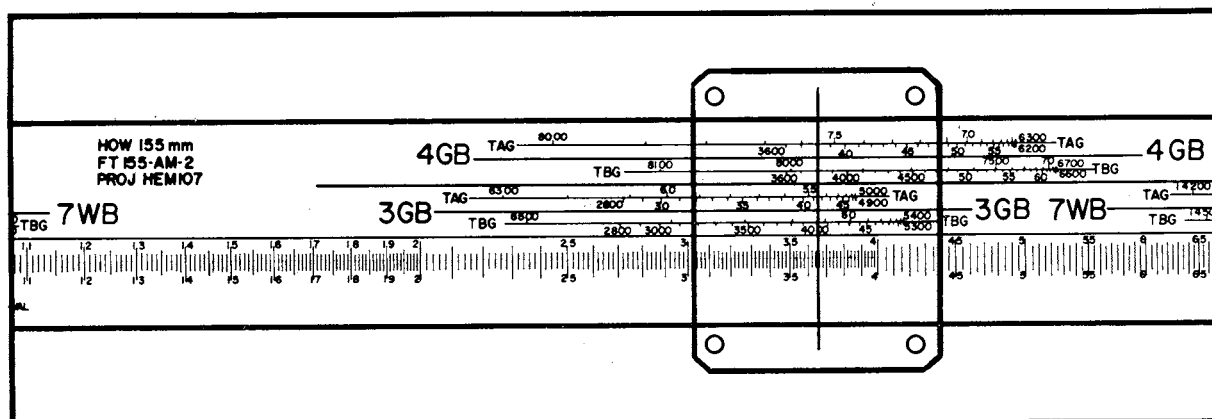


Figure 7-6. Graphical site table.

(1) **Base.** The base is marked with the D-scale (site and VI). The marking of the D-scale is identical to that of the logarithmic D-scale of the military slide rule. This scale represents the values of VI, vertical angle, angle of site, and site.

(2) **Slide.** The slide is marked with a C-scale, gage points, and site-range scales.

(a) **C-scale.** The C-scale (range) is used with the D-scale to perform multiplication and division. The C- and D-scales and the M-gage point are used for computing VI, vertical angle, and angle of site.

(b) **Gage points.** The C-scale is also marked with meter (M) and yard (YD) gage points. The M gage point is used to multiply the value opposite the C-index by 1.0186. This procedure gives an immediate and precise solution to the mil relation ($\frac{W}{R} = 1.0186$). Use of the M gage point is required when the VI and range are in the same unit of measure. The YD gage point is used to multiply the value opposite the M-gage point by 0.9144. This procedure gives an immediate solution to the formula $\text{YARDS} \times 0.9144 = \text{METERS}$.

(c) **Site-range scales.** The site-range scales are used to compute site when the VI and range are known or to compute the VI when the site and range are known. For each charge indicated, there are two site-range scales—one is black, marked TAG (target above gun), and the other is red, marked TBG (target below gun). Each scale is placed in relation to the M-gage point so that site is read on the D-scale opposite the M-gage point when VI on the D-scale is divided by range on the site-range scale. The TAG and TBG scales are constructed to include comp site. They differ from each other just as the comp site factor for a plus angle of site differs from the comp site factor for a minus angle of site. The TAG scale is used when the VI or site is plus, and the TBG scale is used when the VI or site is minus. The value of site is read or placed opposite the M-gage point.

(3) **Cursor.** The cursor has a vertical hairline and serves the same purpose as the indicator of a military slide rule; that is, it enables the user to place or read a value on the slide opposite another value on the base.

c. **Range Changeover Point.** On all GSTs for all charges there is a point on all TAG and TBG scales where the scales begin to "double back"; that is, the cursor is moved to the left rather than to the right for an increase in range for a given vertical interval. The range at which each scale reverses direction is called the range changeover point. The location of the changeover point can be shown by plotting site as a function of site in mils and range in meters. Remember, site equals the angle of site plus comp site. In figure 7-7 at the lower ranges (5,000 to 7,000 meters), the angle of site is decreasing more than comp site is increasing; thus, site decreases. At the longer ranges (8,000 to 9,000 meters), the angle of site is decreasing less than the comp site is increasing; thus, site increases. The site curve shows decreasing values up to a range of approximately 7,600 meters and then shows increasing values beyond. The range at which site is an absolute minimum value is 7,600 meters and is thus the range changeover point.

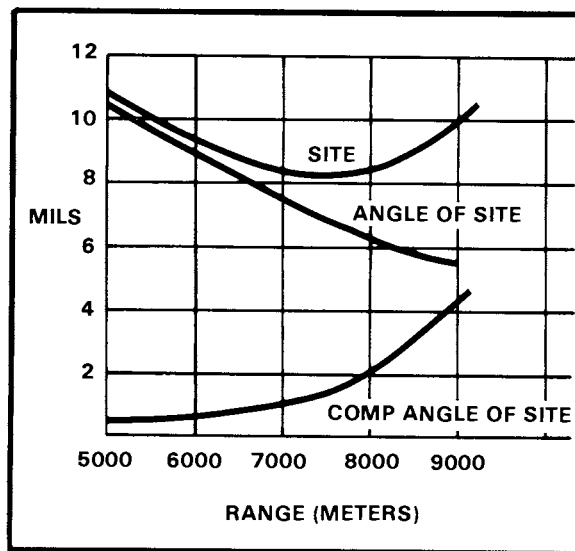


Figure 7-7. Range changeover point, charge 4 GB.

7-11. DETERMINATION OF VERTICAL INTERVAL

When the altitude of the target is determined and the altitude of the battery is

known, the next step is to compute the VI (difference in altitude between the battery and the target). The altitude of the battery is always subtracted algebraically from the altitude of the target. The VI is computed to 1-meter accuracy and must be expressed as plus or minus. For example, if the battery altitude is 376 meters and the target altitude is 354 meters, the VI is -22 meters (354 - 376). A VI can also be computed in reference to an observation post by algebraically subtracting the altitude of the observation post from the altitude of the target. If the desired point of burst is to be at an altitude other than the target altitude, the VI is computed to the burst altitude instead of the target altitude.

Note. The above computation is not performed on the GST.

7-12. COMPUTATIONS WITH THE GST

a. Multiplication and Division. The scales are read and multiplication, division, and rough computation for the decimal point location are performed on the GST in the same manner as they are on the military slide rule.

b. Computation of Angle of Site. For computation of angle of site, the range to the nearest 10 meters and the VI to the nearest meter are used. The answer is read opposite the M gage point to the nearest 1 mil.

(1) Move the hairline over the VI value on the vertical interval (D) scale.

(2) By moving the slide, set the range to the nearest 10 meters on the range (C) scale under the hairline.

(3) Read the value opposite the M gage point on the D-scale. Determine the decimal point location by making the value of the angle as large as possible without exceeding the value of the vertical interval. Express the result to the nearest mil for the angle of site, which must have the same sign as that of the vertical interval.

EXAMPLE:

The VI is +37 meters and the range is 5,460 meters. To compute the angle of site, move the hairline over 37 on the D-scale. Move the slide until 5460 on the C-scale is under the hairline. Read 691 opposite the M gage point. The largest value that does not exceed 37 is 6.91. The VI is plus; therefore, the angle of site is +6.91 expressed as +7 mils (fig 7-8).

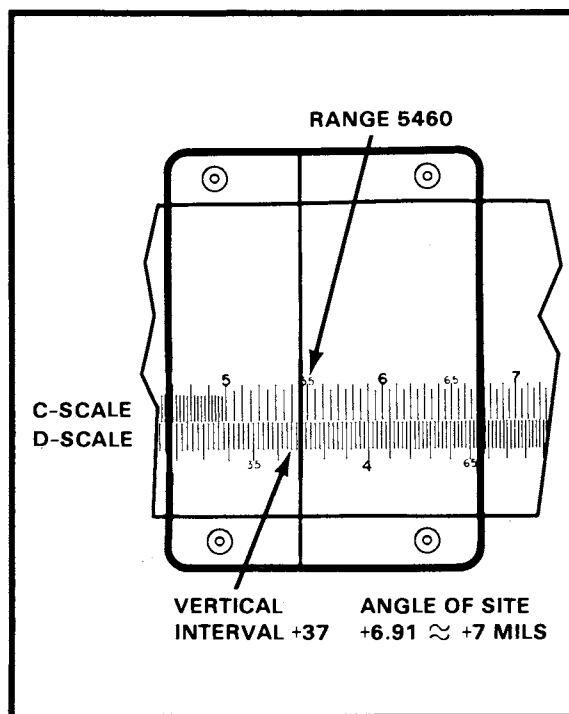


Figure 7-8. Graphical site table position for angle of site for a vertical interval of +37 at a range of 5,460 meters.

c. Computation of Vertical Angle. A vertical angle is computed in the same manner as an angle of site.

d. Computation of Site. To compute site, use the appropriate site-range scale instead of the range (C) scale so that comp site is automatically added to angle of site.

(1) Move the hairline over the VI value on the vertical interval (D) scale.

(2) By moving the slide, set the range to the nearest 10 meters on the appropriate site-range scale under the hairline.

(3) Read the value opposite the M-gage point. Determine the decimal point location, express the result to the nearest 1 mil, and use the same sign as that of the vertical interval.

EXAMPLE:

The VI is +37 meters and the range is 5,480 meters. Charge 4GB GST 155-AM-2 is used. To compute the site, move the hairline over 37 on the D-scale. Move the slide until range 5480 on the site-range scale (chg 4, TAG) is under the hairline. Read 788 opposite the M gage point. Site is +8 mils ($+37 \div 5$ rough division). See figure 7-9.

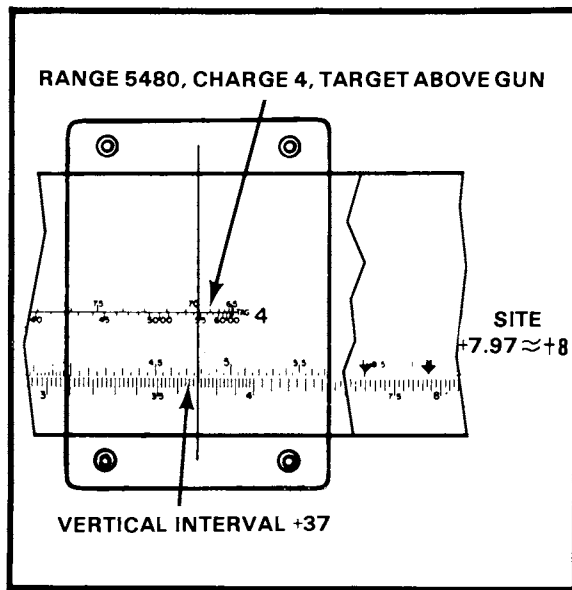


Figure 7-9. Graphical site table position for computing site for a vertical interval of +37 at a range of 5,480 meters.

e. Computation of Comp Site. Comp site can be computed to the nearest one tenth mil by use of the graphical site table.

(1) Compute the angle of site to the nearest 0.1 mil.

(2) Compute the site to the nearest 0.1 mil.

(3) Algebraically subtract the angle of site from site.

(4) The remainder, with its sign, is comp site to the nearest 0.1 mil.

EXAMPLE:

VI is +37 meters and range is 5,480 meters. Charge 4GB GST 155-AM-2 is used. Angle of site is +6.9 mils. Site is +7.9 mils. Therefore, comp site is $(+7.9) - (+6.9) = 1.0$ mil.

f. Computation of Vertical Interval.

The VI can be computed with the GST by a reverse procedure (multiplication by use of the formula $VI = \angle R$) when the angle of site, site, range or distance, charge, and weapon are known.

(1) Move the slide until the M-gage point is opposite the value of the angle (angle of site, vertical angle, or site) on the D-scale.

(2) Move the hairline over the range (to the nearest 10 meters) on the C-scale when angle of site or vertical angle is known and on the appropriate site-range scale when site is known.

(3) Read the value under the hairline on the D-scale. Determine the decimal point location, express the result to the nearest 1 meter, and affix the same sign as that of the angle.

EXAMPLE:

Site, range, and charge are known. The site is +5 mils and the range is 4,650 meters. Charge 4GB GST 155-AM-2 is used. Compute the vertical interval. Move the slide until the M gage point is opposite 5 on the D-scale. Move the hairline over range 4650 on the charge 4 TAG site-range scale. Read 211 under the hairline on the D-scale. The VI is therefore +21 meters $([+5] \times [4.65])$.

g. Limitations of the GST. The angle of site limitation for use of the GST is ± 100 mils, because at this point, the mil relation begins to break down, and an error exceeding 1 mil is introduced. When the angle of site exceeds ± 100 mils, use the following formula $\tan \angle \text{site} = VI/R$.

EXAMPLE:

Vertical interval = 600 meters
Chart range = 5,000 meters
 $\tan \angle \text{site} = 600 - 5000 = 0.12000$
 $\angle \text{site} \tan 0.12$ (TM 6-230, table IV) = 122 mils

Then compute site as described in paragraph 7-15. If the limitations are not exceeded, the maximum error in computations obtained with the GST will not exceed 1 mil.

7-13. DETERMINATION OF ANGLE OF SITE AND VERTICAL ANGLE WITHOUT A GST

a. Angle of Site and Vertical Angle Less Than ± 100 Mils.

(1) **Angle of site.** When the VI and chart range are known, the angle of site is determined by mil relation ($\phi = W/R$) where ϕ is the angle of site, W is the VI, in meters, between the piece and the target or point of burst, and R is the range to the nearest 100 meters, expressed in thousands. For example, range 4,060 is expressed as 4.1. Angle of site is computed to the nearest one tenth mil. The angle of site is a signed value and has the same sign as the VI. The angle of site is plus when the target is above the piece. It is minus when the target is below the piece.

EXAMPLE:

FT 155-AM-2, charge 4GB, is used. Battery altitude is 431 meters. The following call for fire is received:

ADJUST FIRE, SHIFT AF7821, OVER. DIRECTION 5710, RIGHT 200, ADD 700, DOWN 30.

The chart range to the plotted target location is 4,790 meters. Compute the angle of site.

Computation of target altitude:

Target AF7821	451 meters
Subtract 30 (observer's DOWN 30)	-30 meters
Target altitude	421 meters

Computation of VI and angle of site:

Target altitude	421 meters
Subtract battery altitude	-431 meters
Vertical interval	-10 meters

Angle of site = $VI/R = 10/4.8 = -2.08$, or -2.1 mils.

The angle of site is minus, because the target altitude is lower than the battery altitude.

(2) **Vertical angle.** Vertical angle is computed in the same manner as angle of site, except the observer altitude and distance to the target are used instead of the battery altitude and gun-target range.

b. Angle of Site and Vertical Angle Greater Than ± 100 Mils.

(1) **Angle of site.** An angle of site greater than +100 mils must be computed by use of the formula $\tan \angle \text{site} = VI/R$.

(2) **Vertical angle.** A vertical angle greater than ± 100 mils is computed in the same manner as angle of site greater than ± 100 mils.

7-14. DETERMINATION OF VERTICAL INTERVAL WITHOUT A GST

The VI can be computed ($VI = \phi R$) when the angle of site and range or the vertical angle and distance are known.

EXAMPLE:

An observer desires to determine the altitude of a target. The altitude of the OP is 263 meters. The vertical angle from the OP to the target is -4 mils. The estimated distance from the OP to the target is 1,600 meters. Compute the target altitude. Computation of VI and target altitude is as follows:

Distance to target, in thousands	1.6
Multiplied by the vertical angle	$\times (-4) \text{ mils}$
VI	-6.4, $\approx$ -6 meters
OP altitude	263 meters
Add VI	+ (-6) meters
Target altitude	257 meters

7-15. DETERMINATION OF COMPLEMENTARY ANGLE OF SITE WITHOUT A GST

a. The complementary angle of site is computed by multiplying a plus (minus)

angle of site times the value of the complementary angle of site for a plus (minus) 1-mil angle of site. This value is found in column 12 (or 13) of the supplementary data table (table G) of the tabular firing table and is commonly called the comp site factor. The comp site factor must be determined by interpolation of the chart range to the nearest 100 meters. Comp site, which is computed to 0.1 mil, is a signed quantity taking the sign of the comp site factor.

b. A study of listed values for the comp site factor reveals that for short ranges, the comp site factor is negligible. As the range increases, the factor increases for any given charge. Thus, at greater ranges, the comp site factor is significant, even for small angles of site. The comp site factor also varies with the charge for any given range.

EXAMPLE 1:

FT 155-AM-2, charge 4GB, is used. Chart range is 5,000 meters and angle of site is +7.1 mils (target above battery position). Compute the comp site.

Computation of site:

Comp site factor for a +1 mil angle of site, range 5000 (table G, column 12, TFT 155-AM-2),

	+0.103 mil
Multiplied by	
angle of site	× 7.1 mils
Comp site	+0.7313, ≈ +0.7 mil

EXAMPLE 2:

FT 155-AM-2, charge 4GB, is used. Chart range is 6,500 meters and angle of site is -1.2 mils (target below battery position). Compute the comp site. Computation of the comp site factor for a -1 mil angle of site (table G, column 13, TFT 155-AM-2) is -0.238. Comp site is -0.3 mil.

7-16. DETERMINATION OF SITE WITHOUT A GST

Site is the algebraic sum of angle of site and comp site. Site is a signed value and is expressed to the nearest 1 mil.

EXAMPLE:

FT 155-AM-2, charge 4GB, is used. Battery altitude is 270 meters, target altitude is 301 meters, and chart range is 4,710 meters. Compute the site.

Computation of VI:

Target altitude	301 meters
Subtract battery altitude	-270 meters
VI	+ 31 meters

Computation of angle of site = $(+31) \div (4.710) = +6.6$

Computation of comp site = $(0.086) \times (6.6) = +0.5676 \approx +0.6$

Computation of site = $(+0.6) + (+6.6) = +7.2 \approx +7$

7-17. AVERAGE SITE

a. A considerable amount of time can be saved in mission processing if average site can be precomputed for the area of operations.

b. As time permits, the VCO develops a color-coded average altitude map (fig 7-10). He then determines average site to each color-coded band.

c. This technique may not be practical in certain situations; for example, in mountainous terrain or in fast-moving situations where the VCO could use the altitude of the nearest replotted target. If speed is essential, the FDO can announce IGNORE SITE in the fire order.

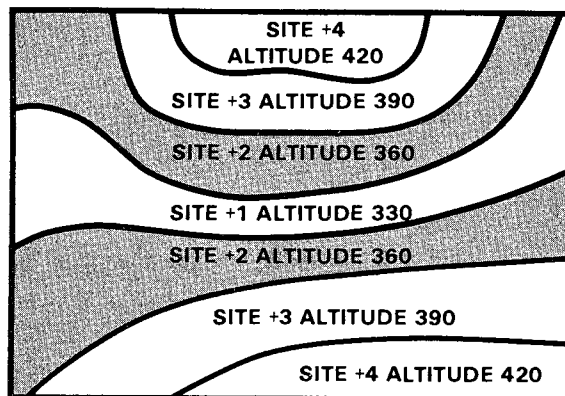
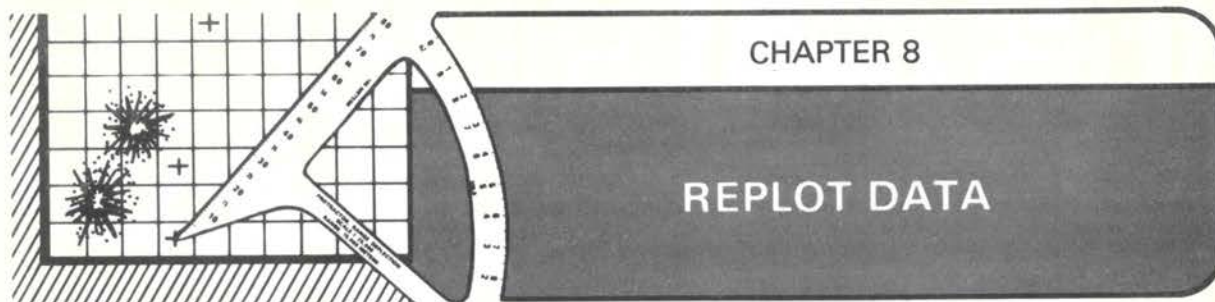


Figure 7-10. The average altitude map (color coded and marked with average site).



In many instances, fire-for-effect data may not reflect the actual location of the target as defined by its chart coordinates and altitude. This inaccuracy results from errors in initial target location and errors in determining the initial site fired in an adjust fire mission. For the observer to accurately shift from a known point located by replot or for other units to mass fires on the same point, the actual target location and altitude must be determined as accurately as possible. To do this, the replot process is used.

a. Replot gives a deflection and range with which the actual target

location can be polar plotted from the location of the firing battery. The manual replot procedures for point detonating (PD) and VT fuzes are the same. The procedures for a time fuze are somewhat different. Targets are replotted on request of the observer or the fire support officer or when directed by the fire direction officer.

b. At times, an observer is unable to locate a target accurately. Inaccurate target location may result in an inaccurate altitude and an inaccurate site being determined by the fire direction center. For example (fig 8-1), if the observer locates a target at a higher

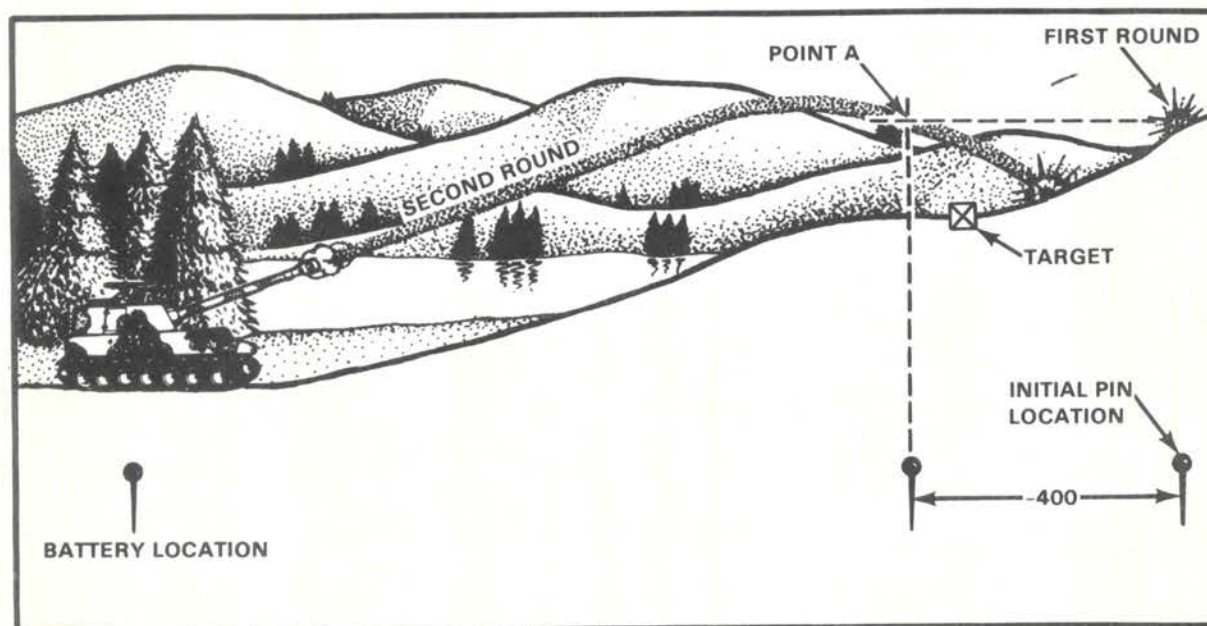


Figure 8-1. Second target location.

altitude than that of the actual target, site is determined on the basis of an incorrect altitude. The observer sends a correction of DROP 400. The data are computed to cause the round to impact at point A, because no adjustment has been made to altitude. The projectile continues and impacts over the target. In figure 8-2, it can be seen that with the observer's next correction (DROP 50), accurate fire for effect is obtained. It can also be seen that there is a difference between the final pin location on the firing chart and the actual target location. Target replot is required to correct for this error. Replot procedures use successive approximation for fuzes

quick and variable time to determine the true site and the actual (replot) range and deflection to the target.

c. To replot a target accurately, a map, accurate refinement data from the observer, and a valid GFT setting are required by the fire direction center. A valid GFT setting is one that accurately portrays the corrections for nonstandard conditions at the time the mission was fired. The GFT settings may prove to be invalid because of weather changes or survey errors. If a valid GFT setting for the time of firing is determined, it is used to replot the target.

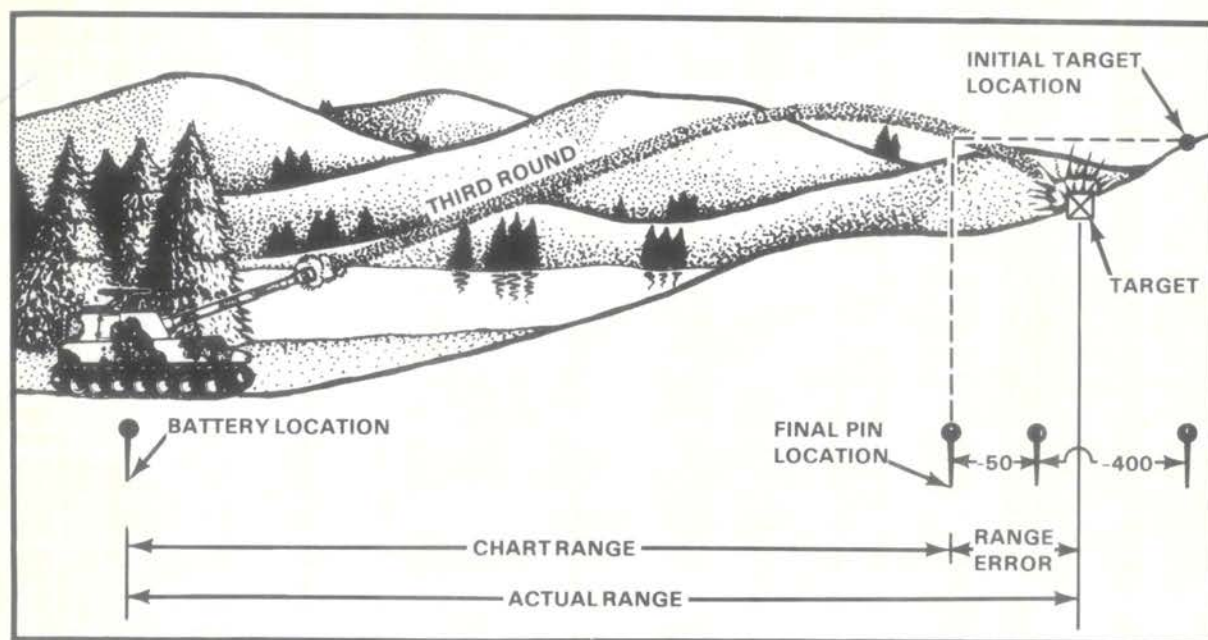


Figure 8-2. Observer's final correction.

Section I MANUAL PROCEDURES

8-1. POINT-DETONATING AND VARIABLE TIME FUZE (M728) REPLOT

a. Replot Deflection. The replot (true) deflection to the target may or may not be the

final piece deflection. Because drift may have changed during the conduct of the adjustment, the true total deflection correction is determined as follows:

(1) After determining final piece data from the observer's refinement, determine the first apparent elevation.

(2) Determine drift corresponding to the first apparent elevation.

(3) Add the drift, determined in the same manner as in (2) above, to the GFT deflection correction. The resulting data are the true total deflection correction. Then determine the replot deflection by subtracting the true total deflection correction from the final piece deflection.

b. Replot Grid and Altitude. The replot grid and altitude are determined by successive approximation. The procedures are described below.

(1) To determine the first apparent elevation, the battery computer subtracts site from the final quadrant. The computer determines the replot deflection as outlined in paragraph *a* above and announces it to the horizontal control operator. The computer then determines the range corresponding to the first apparent elevation. He reads the range under the MHL where the elevation gage line is placed on the first apparent elevation and announces this range to the horizontal control operator.

(2) The HCO polar plots the target from the battery center at the deflection and range announced by the computer and announces the plotted grid to the vertical control operator.

(3) The VCO plots the grid and determines the map altitude at the replotted location. Using the new altitude and the range last announced by the computer, the VCO computes the first apparent site and announces it to the computer.

(4) The computer determines if the first apparent site is within ± 1 mil of the last computed site fired.

(a) If the first apparent site is within ± 1 mil of the last computed site fired, the site is considered true site. To determine true elevation, the computer subtracts the true site from the final quadrant. Using the procedure described in (1) above, the computer determines the replot range. The replot deflection remains the same throughout the process of successive approximation. The computer announces the final replot deflection and range to the horizontal control operator. The HCO announces the replot grid to the computer. The VCO announces the

altitude used to determine true site. This altitude is replot altitude.

(b) If the site is not within ± 1 mil of the last computed site, the steps in (1) through (3) above are repeated until a true site is determined that agrees within ± 1 mil of the last computed site. A completed record of fire is in figure 8-3. Table 8-1 is an example of a replot mission (proximity fuze [M728]).

EXAMPLE:

Given: M109A3 (FT 155-AM-2)
GFT B: Chg 4, Lot XY, Rg 5270, El 350, Ti 19.9
Tot Df Corr: L2: GFT Df Corr: R5

RECORD OF FIRE

CALL FOR FIRE						TGT 380 BTRY 355 V1 +25		GFT R5 DFT L5		Δ FS 100/R 26 /R 20/R 5 HOB Corr SI +7 EI 243 QE (250)							
Observer BGH23 AP(FPE)IS/S Tgt																	
Grid:																	
Polar:Dir Dis U/D VA																	
Shift AA7050 Dir 0540 UR 350 +- 200 U/D																	
SQD IN DRAW , VT						Si ÷ 10		10m Si									
FIRE ORDER ⑤ AMC						Df Corr 0		SI +7									
INITIAL FIRE COMMANDS JMF MF BTRY ⑤ Rg 3960						Chf Df 3209		EI 243									
Sp Instr SPEC CORR AMC Sh Lot XY Chg 4 Fz VT Ti 14.0						Df (3209)		QE (250)									
MTO J ⑤						PF _a		TF		in Eff Ammo Exp							
Tgt	Location	Priority	Firing Unit	SUBSEQUENT FIRE COMMANDS										Exp	Type		
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si ()	EI	QE			
				R PLT		13.0	3209	L30	3239	-15		250	235	(10)			
				CTR PLT		14.0	3209	R 8	3201	0		250	250	(20)			
				L PLT		15.0	3209	R38	3171	+15		250	265	(30)	V7		
	R30	+100	REC	EOM		(15.0)	3187	φ	(3187)	4050	+7	249	(256)				
ASTGT,	EOM	EST	IDC														
CMPTR →	HCO			Replot DF	3187, RG 4050					1st App EL	249						
HCO →	VCO			Replot GRID	61163651												
VCO →	CMPTR			(ALT 355) SITE A+O →						1st App Si+O							
CMPTR →	HCO			Replot DF	3187, RG 4140					2nd App EL	256(QE 256+0=EL)						
HCO →	VCO			Replot GRID	61173659												
VCO →	CMPTR			(ALT 360) SITE A+I						TRUE SITE +I							
CMPTR →	HCO			REPLIST DF	3187 RG 4130					TRUE EL 255(QE 256-1=EL)							
HCO →	CMPTR			REPLIST GRID	61163660												
Btry A	DTG 5/22/84 1430					Tgt AA7060					Replot Grid 61163660					Replot Alt 360	

DA FORM 4504
1 OCT 78

REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE

FOR USE OF THIS FORM, SEE FM 6-40;
THE PROPONENT AGENCY IS TRADOC

Figure 8-3. Completed record of fire—proximity fuze (M728).

Table 8-1. Example of replot mission—proximity fuze (M728).

STEP	COMPUTER	HORIZONTAL CONTROL OPERATOR	VERTICAL CONTROL OPERATOR
1	Determines first apparent elevation: Final QE (256) – site fired (+7) = 249		
2	Determines total replot deflection correction: GFT deflection correction (R5) + drift correspond- ing to the first apparent elevation (L5) = 0		
3	Determines replot deflection: Total replot deflection correction (0) – final piece deflection (3187) = 3187		
4	Determines range: Range corresponding to first apparent elevation 249 = 4050		
5	Announces: REPLOT DEFLECTION 3187 RANGE 4130	Polar plots grid. Measures and announces grid to VCO: GRID 61163651	Plots grid. Determines altitude: Altitude 355 Determines vertical interval: VI = 355 – 355 = 0 Computes first apparent site: GST 4050(TAG) First apparent site = 0 Announces to computer: SITE ALFA 0
6	Determines that the site determined is not within +1 mil of previous site fired; it is not the true site. Determines second apparent elevation: Final QE (256) – first apparent site (0) = 256		
7	Determines and announces replot range: Range corresponding to elevation 256 = 4140 Announces: REPLOT DEFLECTION 3187 RANGE 4140	Polar plots range and deflection; measures and announces REPLOT GRID:	Plots grid. Determines altitude: 360 Determines vertical interval: +5

Table 8-1. Example of replot mission—proximity fuze (M728) (continued)

STEP	COMPUTER	HORIZONTAL CONTROL OPERATOR	VERTICAL CONTROL OPERATOR
8	Determines that the site determined is within +1 mil of previous site computed; it is the true site. Determines true elevation: Final QE (256) - true site (+1) = 255	REPLOT GRID: 61173659	Computes second: apparent site: GST +5/4140 Second apparent site = +1 Announces: SITE ALFA +1
9	Determines and announces replot (true) range corresponding to elevation 255 = 4130 Announces: REPLOT DEFLECTION 3187 RANGE 4130	Polar plots final replot range and deflection; measures and announces: REPLOT GRID 61163660. He then tick marks in black and labels the final pin location.	Announces: REPLOT ALTITUDE 360
10	Records replot grid and altitude on record of fire.		

8-2. VARIABLE TIME FUZE (M513/M514) REPLOT

When a target is attacked with VT fuze M513/M514, a height-of-burst correction (20/R initially determined) is added to raise the trajectory. To replot with the VT fuze, that height-of-burst correction must be subtracted from the final quadrant. This provides the final ground quadrant. The site is subtracted from the final ground quadrant to determine the first apparent elevation. The procedures are then the same as those used for the PD fuze.

EXAMPLE:

STEP	COMPUTER
1	Determines final ground QE: Final QE (374) - 20/R (×4) = 370
2	Determines first apparent elevation: Ground QE (370) - site fired (-11) = 381
3	Supervises FDC team in successive approximation procedures

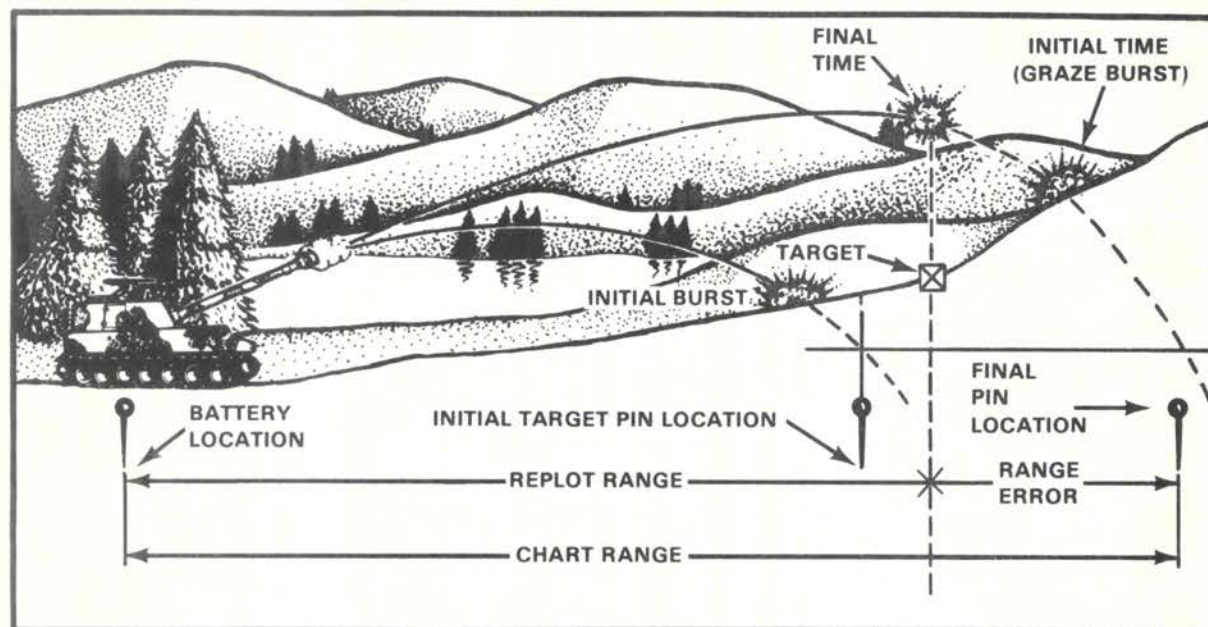


Figure 8-4. Time replot.

8-3. MECHANICAL TIME FUZE REPLOT

a. When a target is attacked with a mechanical time fuze, the height of burst is adjusted by the observer to 20 meters above the target. The final fuze setting provides an accurate representation of the target location and the altitude of a point 20 meters above the target (fig 8-4). Consequently, when the time gage line is placed over the final time, the range and 100/R (read under the MHL) and the elevation and drift correction (read under the elevation gage line) are true. The replot grid and altitude can then be determined.

b. The replot procedures are as follows:

- (1) Place the time gage line over the final time.
- (2) Read replot range and 100/R under the manufacturer's hairline.
- (3) Read drift under a line parallel to the manufacturer's hairline passing through the elevation gage line.

c. To determine the true total deflection correction, determine the replot deflection by adding the drift determined in (3) above to the GFT deflection correction. Then subtract this true total deflection correction from the final piece deflection.

d. Replot grid and altitude are determined as follows:

(1) The computer determines replot range and deflection as in *b* and *c* above and announces them to the horizontal control operator.

(2) The HCO polar plots the target by using the replot range and deflection and determines the replot grid.

(3) The computer subtracts the true elevation from the final quadrant and obtains true total site.

(4) To obtain true ground site, the computer determines the value of 20/R and subtracts the value from the total site fired.

(5) The VCO determines the VI by multiplying the true ground site by the replot range with the M gage point of the GST. He then algebraically adds the VI to the battery altitude and announces the sum to the computer as the target altitude. A completed record of fire is in figure 8-5. Table 8-2 is an example of a replot mission (time fuze).

EXAMPLE:

Given: M109A3 (FT 155-AM-2)

GFT A: Chg 4, Lot XY, Rg 5140, El 335, Ti 18.9

GFT Df Corr: R5, Tot Df Corr: L2

RECORD OF FIRE

Observer BGH23		CALL FOR FIRE		TGT 365		GFT R5		Δ PS .13								
Grid: 611369		ADJ#1/S		BTRY 355		DFT L5		100/R 23								
Polar: Dir _____ Dis _____ U/D _____ VA _____		U/D _____		VI +10				/R _____								
Shift: Dir _____ U/R _____ +/- _____ U/D _____		PLT IN TRENCH LINE, VT		Si $\div$ 10		10m Si		20/R 5								
FIRE ORDER Ti 1/6 (5)		Df Corr 0		Si +2												
INITIAL FIRE COMMANDS		(FM) MY BTRY ADJ #4 (1)		Rg 4430		Chf Df 3196		EI 278								
Sp Instr _____		Sh _____		Lot _____		Chg 4 Fz _____		Df 3196 QE 280								
MTO J Ti 1/6 (5) TGT # AA7061		4 T		PER _____		TF _____		(5) FZ Ti in Eff Ammo Exp (1)								
Tgt	Location	Priority	Firing Unit	SUBSEQUENT FIRE COMMANDS										Exp	Type	
(Dir) MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	PS Corr	Ti	Chart Df	Df Corr (0)	Df Fired	Chart Rg	HOB Corr	Si (+2)	EI	QE		
0700	L40	+100					3190	0	3190	4540		+2	286	288	(2)	Q✓
Ti		-50		FZ Ti		16.2	3197	0	3197	4510	+5	+7	284	(291)	(1)	
	DISFFE			BTRY (5) +0.2 (16.4)					3197					(291)		
				SPEC CORR												
				R PLT	15.5	15.7	3197	L26	3223			-13	291	278		
				CTR PLT	16.0	16.2	3197	R6	3191			0	291	291		
				L PLT	17.0	17.2	3197	R33	3164			+14	291	305	(3)	Ti✓
	R40	+40	DS			16.2	TRIAL	TIME								
EOM	PLT	NE VT		EOM	+0.2	(16.4)	3188	0	(3188)	4520	-1	+6	285	(291)		
Ti GAGE LINE 16.4 $\leftarrow$ EL GL EL 288 DFT L6 MHL RG 4560 100/R 22 29/R4																
Btry A		DTG 5/22/84 1430		Tgt AA7061		Replot Grid 61153720		Replot Alt 351								

DA FORM 4504
1 OCT 78

REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE

FOR USE OF THIS FORM, SEE FM 6-40;
THE PROONENT AGENCY IS TRADOC

Figure 8-5. Completed record of fire—time fuze.

Table 8-2. Example of replot mission—time fuze.

STEP	COMPUTER	HORIZONTAL CONTROL OPERATOR	VERTICAL CONTROL OPERATOR
1	Places the time gage line over the final time and determines replot information: Reads information from MHL: 100/R 22 Replot Range 4560 Reads information from elevation gage line: True elevation 288 Drift L6		
2	Determines total replot deflection correction: GFT deflection correction (R5) + drift (L6) = L1		
3	Determines replot deflection: Final piece deflection (3188) - total replot Deflection correction (L1) = 3187		

Table 8-2. Example of replot mission—time fuze. (continued).

STEP	COMPUTER	HORIZONTAL CONTROL OPERATOR	VERTICAL CONTROL OPERATOR
4	Announces: REPLOT DEFLECTION 3187 RANGE 4560	Polar plots data and announces: REPLOT GRID 61153720.	
5	Determines true ground site: Final QE 291 -True elevation 288 True total site +3 -20/R +4 True ground site -1 Announces: SITE ALFA -1	Determines target altitude.	
6			True ground site -1 X range (GST) x4560 VI -4 +battery altitude 355 Announces: REPLOT ALTITUDE 351
7	Records replot grid and altitude on record of fire.		

Section II

COMPUTER PROCEDURES

8-4. FADAC REPLOT

FADAC provides a quick means for replotting targets. It determines the replot location by recomputing the ballistic trajectory and displaying the grid and altitude of the point of impact. The replot procedures are the same for all fuzes and are found in the FADAC job aids.

8-5. BATTERY COMPUTER SYSTEM REPLOT

The BCS performs replot functions similar to those for manual procedures. Two operator methods are used depending on whether the observer requested the target be recorded or not. These procedures are explained in the BCS job aids.



CHAPTER 9

FIRING DATA PROCEDURES

This chapter describes characteristics of and firing data procedures for various munitions. Manual firing data solution procedures are also listed with corresponding examples based on multiplot GFT settings, SOPs, and known data from appendix I. The examples include special corrections (chap 13). Data in these examples are computed for three 2-gun platoons. This provides a means for manual computation for units that must occupy large frontages without a battery computer system. Each family of ammunition has a base projectile that is normally used to determine registration corrections for the family. It serves as the foundation for determining firing data for all other members of that ammunition family. Normally, an ammunition family for a particular weapon system includes all the projectiles listed on the cover of the TFT for the family's base round. The characteristics of different types of projectiles and certain types of missions require special consideration by the fire direction center.

a. The entry range for computing unit firing data factors from the firing tables or from the ballistic computers will be chart range. This is determined to the point at which the observer desires the ammunition fired. Normally, in manual procedures, it is not necessary or practical to determine complementary range, because the possible increased accuracy does not justify the additional time required for computing complementary range.

CALL FOR FIRE BLOCK
USED TO RECORD CALL FOR FIRE. THE COMPUTER CIRCLES OR FILLS IN THE APPROPRIATE DATA DEPENDING ON WHETHER THE MISSION IS ADJUST FIRE, FIRE FOR EFFECT, IMMEDIATE SUPPRESSION, OR SUPPRESS.

FIRE ORDER BLOCK
USED BY THE COMPUTER TO RECORD THE FIRE ORDER.

COMPUTATION SPACE
USED BY THE COMPUTER TO RECORD AND DETERMINE PERTINENT DATA.

NOTE: NO GFT SETTINGS AVAILABLE

Observer <u>H16</u>		CALL FOR FIRE AP/FEE/IS/S		Tgt		ALT <u>AB 8472</u> 428 GFT - <u>△ PS</u>		100/R <u>21</u>	
Grid:						DRAFT <u>L6</u>		/R	
Polar: Dir <u>AB 8472</u>		Dis <u>1020</u>		U/D <u>210</u>		VA <u>400</u>		20/R <u>4</u>	
Shift <u>250 23-4, VT 1/2</u>								MOB Corr	
FIRE ORDER <u>③, VT 1/2</u>						Si ÷ 10		10m Si	
INITIAL FIRE COMMANDS		FM MF <u>BTRY ADT #4 ①</u>		Rg <u>4870</u>		Df Corr <u>L6</u>		Si <u>+6</u>	
Sp Instr		Sh		Lot		Chg <u>4</u> Fz		TI	
MTO <u>647, ③, AC 7879</u>		T (580) <u>640</u>		PER		TF		Df <u>3223</u>	
								Chf Df <u>3217</u>	
								EI <u>295</u>	
								QE <u>301</u>	
								③ VT in Eff	
								Ammo Exp	

MT0 BLOCK
USED BY THE COMPUTER TO RECORD THE MESSAGE TO OBSERVER (MTO), ANGLE T, AND PROBABLE ERROR IN RANGE. TIME OF FLIGHT IS RECORDED WHEN SENT TO THE OBSERVER, OR IT MAY BE RECORDED IN PARENTHESES IF DETERMINED AND NOT SENT TO THE OBSERVER.

INITIAL FIRE COMMANDS
USED BY THE COMPUTER TO RECORD AND TRANSMIT FIRE COMMANDS. THOSE SHADED PORTIONS INDICATE WHAT MUST BE SENT TO THE GUNS.

Figure 9-1. Record of fire—call for fire and initial computation.

the processing and determination of data. It is used for the following:

- (1) Recording the call for fire.
- (2) Computing firing data for all types of missions.
- (3) Keeping a permanent record of fire missions.

Note. Major sections are shown with heavy black lines. Shaded portions show items that must be sent to the cannon sections.

Section I HIGH-EXPLOSIVE MUNITIONS

9-1. CHARACTERISTICS

The HE family of projectiles uses conventional HE rounds as its base rounds. These rounds are the 105-mm M1, the 155-mm M107, and the 203-mm (8-inch) M106 projectiles. Included in this ballistic family are the antipersonnel improved conventional munitions (APICM) (ICM: 105-mm M444, 155-mm M449 series, 203-mm M404), illumination (illum) projectiles (105-mm and 155-mm only), chemical (including white phosphorus, VX, and GB) rounds, and smoke (HC-type) rounds. The introduction to the appropriate weapon TFT has a description of the delivery techniques for the HE base round.

9-2. COMPUTATIONS FOR HIGH-EXPLOSIVE PROJECTILES

a. Description. The HE projectiles are hollow steel cases filled with explosive, normally composition B. They can be fuzed for air, graze, or subsurface burst.

b. High-Explosive GFTs. The high-explosive GFTs are described in chapter 7.

c. Selection of Charge. Selection of the charge to fire is the responsibility of the fire direction officer. He may use the charge selection table in the introduction of the TFT to aid in his selection of the optimum charge for each range. A standard charge can be designated manually for the primary zone of action.

d. Determination of Firing Data. In the manual FDC, the FDO issues a fire order after he receives the call for fire and after he conducts his analysis of the target. If no ballistic computers or hand-held calculators are available, the HCO determines the chart data to the target. The VCO in the manual FDC determines the vertical interval between the battery and the target. He determines and announces site to the computer, who determines the fuze setting (for MT or VT fuzes), deflection, and quadrant elevation to fire. Normally, the manually equipped FDC uses a GFT fan with a GFT setting and graphical site tables to determine firing data. In the fire-for-effect phase, the VCO determines corrections to the battery center to target center firing data from the hasty correction tables and announces these corrections to the computer.

9-3. SAMPLE MISSIONS

a. *Adjust Fire, HE/Quick in Effect.*
Figure 9-3 shows a record of fire for an adjust fire mission with HE/quick in effect.

b. *Adjust Fire, HE/VT in Effect.*
Figure 9-4 shows a record of fire for an adjust fire mission with HE/VT in effect.

Note. In determining corrections for fuze VT, corrected deflection and quadrant are first extracted from the hasty correction tables. Site is then subtracted from the corrected quadrant, and the resulting elevation is used to determine the VT fuze setting.

c. *Adjust Fire, HE/Time in Effect.*
Figure 9-5 shows a record of fire for an adjust fire mission with HE/time in effect.

Notes. 1. In firing fuze time, 20/R must be added to ground site, and the resulting total site must be applied to the elevation.

2. The fuze setting is determined from the initial time fuze setting.

3. The corrected fuze setting is determined by placing the elevation gage line over the corrected elevation and reading the corrected fuze setting under the time gage line.

4. If the request for fire for effect includes a height-of-burst correction, the fuze setting correction is applied to the corrected fuze setting.

RECORD OF FIRE																	
Observer <u>B6H23</u>		CALL FOR FIRE		Tgt		ALT TGT <u>363</u>		GFT R4		△ FS							
Grid: <u>611362</u>		AT/FE/VS/S				ALT BTRY <u>355</u>		DRIFT L4		100/R <u>27</u>							
Polar: Dir		Dis		U/D		VA		VI <u>+8</u>		DF CORR <u>0</u>		/R					
Shift		Dir		L/R		+/		U/D		Si ÷ 10		10m Si		HOB Corr			
SQUAD DIGGING IN, JCM VE																	
FIRE ORDER <u>Q VE (12)</u>		✓		BTRY ADJ, #4 (1)		Rg <u>3720</u>		Df Corr <u>0</u>		Si <u>+2</u>							
INITIAL FIRE COMMANDS		✓		BTRY ADJ, #4 (1)		Rg <u>3720</u>		Df Corr <u>0</u>		Si <u>+2</u>							
Sp Instr		Sh		Lot		Chg <u>4</u>		Fz		Ti		Df <u>3211</u>		QE <u>226</u>			
ATO <u>G, Q VE, (12), AC 7835</u>		✓		T <u>600</u>		PER		TF		(12) in Eff		Ammo Exp (1)					
Tgt	Location	Priority	Firing Unit	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (0)	Df Fired	Chart Rg	HOB Corr	Si (+2)	EI	QE	Exp	Type	
(12) MF SH, Fz	Oev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (0)	Df Fired	Chart Rg	HOB Corr	Si (+2)	EI	QE	Exp	Type	
0520	L100	+50 FFE	BTRY (12)				3234	0	3234	3780		+2	229	231	(2)		
			SPEC CORR				3226	0	(3226)	3820		+2	232	(234)			
			R PLT				3226	L34	3260			-15	234	219	(26)		
			CTR PLT				3226	R8	3218			0	234	234	(50)		
			L PLT				3226	R45	3181			+16	234	250	(24)	Q ✓	
	R10	-20 EM	EM														
SQUAD NEUT ESTIMATE 5 CASUALTIES																	
				R PLT				CTR PLT				L PLT					
				PRC -14				0				+15					
				MVC -1				0				+1					
				-15				0				+16					
Dtry <u>A</u>		DTG <u>3122/84</u>		Tgt <u>AC 7835</u>		Replot Grid		Replot Alt									
DA FORM 450/		REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE								FOR USE OF THIS FORM, SEE FM 6-40; THE PROPOSAL AGENCY IS TRADOC							

Figure 9-3. Low-angle adjust fire HE/quick mission.

Observer <u>B6H23</u>		Tgt _____		TGT ALT <u>390</u>		GMT <u>R4</u>		△ PS								
Grid: <u>615388</u>		AD FFE/IS/S _____		BTRY ALT <u>355</u>		DRIFT <u>L10</u>		100/R <u>16</u>								
Polar: Dir _____ Dis _____ U/D _____ VA _____		Shift _____ Dir _____ U/R _____ +/- _____ U/D _____		VI <u>+35</u>		L6		20/R <u>3</u>								
SURVEY PARTY <u>1/0</u> UT <u>1/E</u>				* Si ÷ 10		10m Si		HOB Corr								
FIRE ORDER <u>(5)</u>						Df Corr <u>L6</u>		Si <u>+7</u>								
INITIAL FIRE COMMANDS				✓ FM MF BTRY ADJ #4 <u>(1)</u>		Rg <u>6310</u>		Chf Df <u>3121</u>								
Sp Instr _____				Sh _____ Lot _____		Chg <u>4</u> Fz _____ Ti _____		Df <u>3127</u>								
MTO <u>G, (5), AC 7836</u>				* <u>(620) 600</u> PER _____		TF _____		<u>(5) UT</u> in Eff								
								Ammo Exp <u>(1)</u>								
SUBSEQUENT FIRE COMMANDS																
Tgt	Location	Priority	Firing Unit	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L6)	Df Fired	Chart Rg	HOB Corr	Si (+7)	El	QE	Exp	Type
<u>(5) Dir MF Sh, Fz</u>	<u>Dev</u>	<u>Rg</u>	<u>HOB Corr</u>													
<u>0650</u>	<u>L50</u>	<u>FFE</u>		<u>BTRY (5)</u>			<u>3126</u>	<u>L6</u>	<u>(3132)</u>	<u>6350</u>		<u>+7</u>	<u>452</u>	<u>(459)</u>		
				<u>SPEC CORR</u>												
				<u>F2 VT</u>												
				<u>R PLT</u>			<u>3132</u>	<u>L18</u>	<u>3150</u>			<u>-21</u>	<u>459</u>	<u>438</u>	<u>(10)</u>	
				<u>C ALT</u>			<u>3132</u>	<u>R6</u>	<u>3126</u>			<u>0</u>	<u>459</u>	<u>459</u>	<u>(20)</u>	
				<u>L ALT</u>			<u>3132</u>	<u>R24</u>	<u>3108</u>			<u>+20</u>	<u>459</u>	<u>479</u>	<u>(30)</u>	<u>VT</u>
			<u>EM</u>	<u>EM</u>												
<u>SURVEY PARTY NEUT EST 10 CAS</u> <u>R PLT</u> <u>PRC -19</u> <u>MVC -2</u> <u>-21</u> <u>C PLT</u> <u>0</u> <u>0</u> <u>0</u> <u>L PLT</u> <u>+20</u> <u>0</u> <u>+20</u>																
Btry <u>A</u>		DTG <u>5122/84</u>		Tgt <u>AC 7836</u>		Replot Grid		Replot Alt								

Figure 9-4. Low-angle adjust fire HE/VT (M728) mission.

Observer B6H23		CALL FOR FIRE (A) FFE/M/S		Tgt	TGT ALT 350 GFT Rq BTRY ALT 355 DFT L6 VI - 5 L2		Δ FS 11
Grid: 595371							100/R 21
Polar: Dir	Dis	U/D	VA				/R
Shift:	Dir	L/R	+/-	U/D			20/R 4
SPIGOT MISSILE POS ICM 1/E					* Si ÷ 10		HOB Corr
FIRE ORDER #3 (8) T1 1/E					Df Corr	L2	
INITIAL FIRE COMMANDS Fm MF BTRY ADJ #3					Rg	4960	
Sp Instr					Sh	Lot	Cbg 4 Fz Ti
MTO GTI 1/E (8) AA7050					* T (310)	PEr	TF
					(6) T1		in Eff
							Ammo Exp (1) Q v

Tgt	Location	Priority	Firing Unit	SUBSEQUENT FIRE COMMANDS												Exp	Type
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Cbg, Fz	FS Corr	Ti	Chart Df	Df Corr (L2)	Df Fired	Chart Rg	HOB Corr	Si (-1)	EI	QE			
6330	T1	+50		FZ T1		18.2	3532	L2	3534	5000	+4	+3	323	326	(1)		
			DIO	FFE BTRYS					3534					(326)			
			FFE	SPEC CDRR													
				R PLT		17.6	3534	L24	3558			-14	326	(312)			
					+0.1	17.6			3558					312	(17)		
				C PLT		18.3	3534	R6	3528			0	326	(326)			
					+0.1	18.3			3528					326	(33)		
				L PLT		19.0	3534	R30	3504			+15	326	(341)			
					+0.1	19.1			3504					341	(48)	T1	
			EM	EM													

Δ FS.11 (USDA)
x 1
+11 ≈ .1

SPIGOT SITE DESTROYED		R PLT	C PLT	LPLT
PRC	- 14	O	+15	
	0	O	0	
	-14	O	+15	

Btry A	DTG 5/22/84	Tgt AA7050	Replot Grid	Replot Alt
--------	-------------	------------	-------------	------------

Figure 9-5. Low-angle adjust fire HE/time mission.

RECORD OF FIRE																						
Observer B6H23 CALL FOR FIRE POLAR Tgt _____ Grid: _____ Polar: Dir 0350 Dis 3980 U/D _____ VA _____ Shift: _____ Dir _____ U/D _____ +/- _____ U/D _____ INFANTRY PLT 1/0 ICM										TGT ALT 375 GFT R4 BTRY ALT 355 DFT L7 VI +20 L3				Δ PS 100/R 20 /R 20/R 4 HOB Corr +4								
FIRE ORDER T1 (18) AMC										Df Corr L3				Si (+4)+8								
INITIAL FIRE COMMANDS MC BTRY (18)										Df 5140				Cht Df 3200				EI 335				
Sp Instr MC SPEC CORR										Sh _____ Lot _____				Cht 1/0 Fi Ti Ti _____				Df (3203) Ei (343)				
MTO GTI (18) AA 7051										4 T _____				PE _____ TF _____				in Eff _____ Approx Exp _____				
Tgt	Location	Priority	Firing Unit	SUBSEQUENT FIRE COMMANDS																		
Dir, MF Sb, Fz	Dev	Dg	HOB Corr	MF, Sb, Ch, Fz	PS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Dg	HOB Corr	()	EI	GE	Exp	Type						
				R PLT			3203	L24	3227				-14	343	329	(36)						
				C PLT			3203	R6	3197				0	343	343	(72)						
				L PLT			3203	R30	3173				+15	343	358	(108)	TIL					
PLT DISP TO THE SOUTH EST CAS 17																	R PLT PRC -14 MVC 0 -14		C PLT 0 0 0		L PLT +15 0 +15	
Dir		DTG		Tgt		Replot Grid		Replot Alt														
DA FORM 4504 1 OCT 76 REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE FOR USE OF THIS FORM, SEE FM 6-60; THE PROPOUNCE AGENCY IS TMADOC																						

Figure 9-6. Low-angle fire-for-effect HE/time mission.

d. *Fire For Effect, HE/Time.* Figure 9-6 shows a record of fire for a fire-for-effect HE/time mission.

Note. 20/R is computed and recorded in the HOB Corr block as shown.

these ICMs can be based on HE firing data. The APICM round is a base-ejection projectile containing grenades that are expelled at a predetermined height of burst (table 9-1).

Table 9-1. Antipersonnel improved conventional munitions.

CALIBER	PROJECTILE	NUMBER OF GRENADES
105 mm	M444	18
155 mm	M449 series	60
203 mm	M404	104

9-4. APICM PROJECTILES

The APICM projectiles are available for the 105-mm, 155-mm, and 203-mm howitzers. The projectile cases are ballistically similar to the HE cases. Therefore, the firing data for

a. GFT Firing Data Computation.

(1) **GFT APICM scales.** Graphical firing tables for the base HE projectiles have APICM scales. There are ballistic differences between the 155-mm M449 and the M449/E1 APICM projectiles. Therefore, different GFT scales are required for each of these types of rounds. Their firing data cannot be interchanged. HOW 155 mm 155AM2HEM107 scales have both the M449 and the M449A1/E1 scales printed on the face of the graphical firing table. All other 155-mm series GFTs have only the M449 scales. For 155-mm systems not using the HOW 155 mm 155AM2HEM107 data, the TFT solution must be used to determine firing data for M449A1/E1 projectiles (para c below).

(2) **GFT ICM scale.** An ICM scale has two parts. One part is for quadrant elevation, labeled QE, and the other part is for fuze setting, labeled FS (fig 9-7). The scale is constructed to compensate for ballistic differences between the base HE projectile and the APICM.

b. TFT Computation. Tabular firing table addendums are published for APICM projectiles to supplement the base HE tabular firing tables. An addendum is divided into sections. Each section contains ballistic correction data for a given propelling charge. Figure 9-8 shows an example section. Each section contains tables as described below:

(1) **Table A.** Table A contains corrections to convert the HE quadrant elevation to the APICM quadrant elevation. It contains range to impact for a nonfunctioning APICM round and correction factors for height-of-burst and range changes.

(2) **Table B.** Table B contains corrections to convert the M564/M582 fuze setting (HE data) to the APICM fuze setting. It also lists antipersonnel fuze setting corrections for height-of-burst and range changes.

(3) **Table C.** Table C contains corrections to convert the M520A1 fuze setting (HE data) to the APICM fuze setting.

(4) **Tables D, E, and F.** These tables are designed for unit self-defense firing of antipersonnel improved conventional munitions.

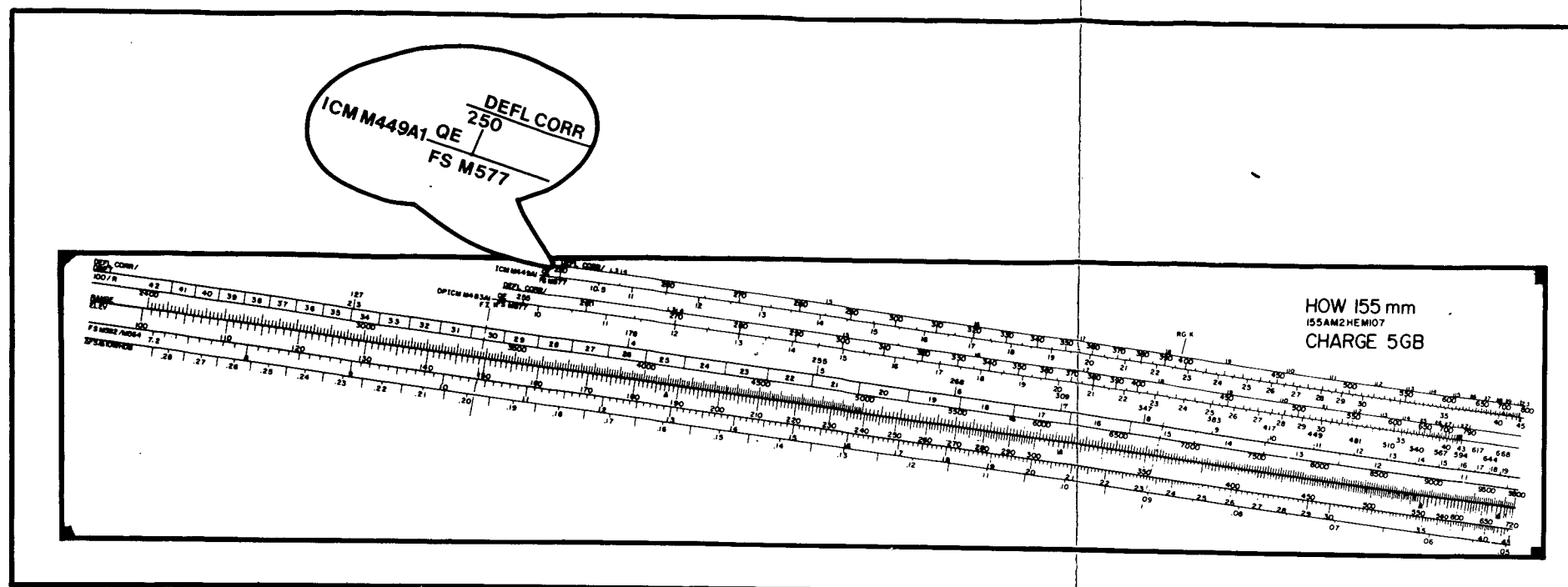


Figure 9-7. M449 scale.

FT 155 ADD-I-1								TABLE A		CHARGE 4G	
PROJ, HE, M449 MODS FUZE, MT, M565								QUADRANT ELEVATION			
1	2	3	4	5	6	7	8				
QUADRANT ELEVATION FOR PROJ, M107	CORRECTIONS TO QUADRANT ELEVATION FOR PROJECTILE,			CORRECTIONS TO QUAD ELEV FOR AN INC OF		CORR FOR LOW LEVEL WIND OF 1 KNOT	RANGE TO IMPACT				
	M449A1	M449	M449E1	50 M IN HGT	100 M IN RG			50 METERS IN HEIGHT	100 METERS IN RANGE		
MILS	MILS	MILS	MILS	MILS	MILS	METERS	METERS				
325	42	38	39	11.2	7.1	3.7	5833				
330	41	37	39	11.1	7.2	3.6	5883				
335	41	36	38	11.0	7.3	3.6	5933				
340	40	36	37	10.9	7.5	3.6	5982				
345	40	35	37	10.8	7.6	3.5	6032				
350	39	34	36	10.7	7.7	3.5	6080				
355	39	34	36	10.7	7.9	3.5	6129				
360	38	33	35	10.6	8.0	3.4	6178				
365	38	32	35	10.6	8.1	3.4	6226				
370	38	32	34	10.5	8.3	3.4	6273				
375	37	31	33	10.5	8.4	3.3	6321				
380	37	31	33	10.4	8.5	3.3	6368				
385	37	30	33	10.4	8.7	3.3	6414				
390	36	30	32	10.3	8.8	3.2	6461				
395	36	29	32	10.3	9.0	3.2	6507				
400	36	29	31	10.3	9.1	3.2	6552				
405	36	28	31	10.3	9.3	3.1	6597				
410	35	28	30	10.2	9.4	3.1	6642				
415	35	27	30	10.2	9.6	3.1	6686				
420	35	27	30	10.2	9.8	3.1	6730				

CHARGE 4G		TABLE B		FT 155 ADD-I-1	
		FUZE SETTING		PROJ, HE, M449 MODS FUZE, MT, M565	
1	2	3	4	5	6
M564 FUZE SETTING FOR PROJ, M107	M449A1	M449	M449E1	CORRECTIONS TO FS FOR AN INCREASE OF 50 METERS IN HEIGHT	CORRECTIONS TO FS FOR AN INCREASE OF 100 METERS IN RANGE
9.6-10.6	-1.3	-1.2	-1.3		0.4
10.7-14.2	-1.2	-1.1	-1.2	0.0	0.4
14.3-17.8	-1.1	-1.1	-1.2	0.1	0.4
17.9-20.8	-1.0	-1.1	-1.1	0.1	0.5
20.9-23.3	-0.9	-1.1	-1.1	0.1	0.5
23.4-25.4	-0.8	-1.1	-1.1	0.1	0.6
25.5-27.1	-0.7	-1.1	-1.0	0.1	0.6
27.2-28.5	-0.6	-1.1	-1.0	0.2	0.7
28.6-29.7	-0.5	-1.1	-1.0	0.2	0.7
29.8-30.8	-0.4	-1.1	-1.0	0.2	0.8
30.9-31.6	-0.3	-1.1	-0.9	0.2	0.9
31.7-32.4	-0.2	-1.1	-0.9	0.3	0.9
32.5-33.0	-0.1	-1.1	-0.9	0.3	1.0
33.1-33.5	0.0	-1.1	-0.9	0.3	1.1
33.6-34.0	0.1	-1.1	-0.8	0.4	1.2
34.1-34.4	0.2	-1.1	-0.8	0.4	1.3
34.5-34.8	0.3	-1.1	-0.8	0.5	1.5
34.9-35.1	0.4	-1.1	-0.8	0.5	1.6
35.2-35.4	0.5	-1.1	-0.7	0.6	1.8
35.5-35.6	0.6	-1.1	-0.7	0.6	2.0
35.7-35.8	0.7	-1.1	-0.7	0.7	
35.9-36.0	0.8	-1.1	-0.7	0.7	
36.1-36.2	0.9	-1.1	-0.7	0.8	

c. **Initial APICM Firing Data Computation.** Compute initial firing data for APICM using the graphical firing table (fig 9-9).

(1) Determine HE firing data to the target. Do not include 20/R when determining HE quadrant elevation.

(2) Using the ICM scales on the GFT, convert the HE fuze setting to the ICM fuze setting. Place the MHL over the HE fuze setting on the FS M564 scale, and read the

ICM fuze setting from the appropriate ICM fuze scale under the manufacturer's hairline.

Note. The APICM piece deflection is the same as the HE piece deflection.

(3) Convert the HE quadrant elevation to the APICM quadrant elevation, and place the MHL over the HE quadrant elevation on the base HE elevation scale. Then read the APICM quadrant elevation under the MHL from the appropriate ICM elevation scale.

GFT SETTING (MANUAL METHOD)										DEFLECTION CORRECTION	
14	GFT	CHARGE	LOT	RANGE	ELEVATION	TIME	TOTAL	GFT			
14	A	4	XY	3790	215	13.1					
15	A	4	XY	4910	300	17.8					
16	A	4	XY	7070	510	28.8	L11	L5			

CALL FOR FIRE				TGT ALT				TGT ALT								
Observer	Grid	Polar/Dir	Shift	AP/FFE/IS/S	Tgt	380 DFT L1	355 GFT L5	100/R	20							
B3H26	625374															
INF CO ADVANCING, ICM 1/E				v1 +25 L12				20/R								
FIRE ORDER SHELL AP/ICM (4)				Df Corr L12				Si +6								
INITIAL FIRE COMMANDS				FM MF BTRY ADJ *4 (1)				Rg 5080								
Sp Instr				Sh Lot XY Chg 4 Fz Ti				Df 2922								
MTD G, (4), TGT AC 7224				*T(240) PEr				TF (4) SHELL APICM LOT FY, FZ, TI in Eff								
SUBSEQUENT FIRE COMMANDS										Ammo Exp (1)						
Dir, MF	Dev	Rg	MOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L12)	Df Fired	Chart Rg	MOB Corr	Si (+b)	EI	QE	Exp	Type
DIR	R60	H00					2892	L12	2904	5160		+6	319	325	(2)	QV
0550		-50	FFE	BTRY (4)		18.7	2896	L12	2908	5110		+6	(315)	(321)	HE	DATA
				SPEC CORR		12.6			2908					(360)	ICM	DATA
				SHELL APICM											(SEE NOTE 1)	
				LOT FY, FZ, TI												
				R PLT											(8)	
				C PLT											(16)	
				L PLT											(24)	
	L100		U100			18.7	2915	L12	2927	5130		+6	317	323	HE	DATA
RPT						12.6								(361)	UNCORR ICM	
TAB B-2	TAB A-21					12.3								(393)	FFE ICM DATA	
O.1		11.2		R PLT											(32)	
X2		X2		C PLT											(40)	
0.2-1.2		22.4	+22	L PLT											(48)	APICM

NOTE 1 ICM DATA IS BTRY CTR TO TGT CTR SOLUTION, SPEC CORR MUST NOW BE APPLIED SEE CHAPTER 13 FOR PROCEDURES
*LOT F IS SHELL M449

Btry A	DTG 5/22/84	Tgt AC 7224	Replot Grid	Replot Alt
--------	-------------	-------------	-------------	------------

Figure 9-9. Sample APICM fire mission with multiplot GFT setting applied (TFT 155-AM-1 data).

d. Subsequent Firing Data Computation. Height-of-burst corrections cannot be made by use of the GFT for antipersonnel improved conventional munitions. Therefore, the APICM tabular firing table addendum must be used to compute all HOB corrections. The correction values in tables A and B, column 5, for an increase of 50 meters in height of burst are applied as positive values. To compute corrections for a decrease in height of burst, change the sign of the correction factor to a negative value. Compute subsequent firing data for APICM by using the graphical firing table and the tabular firing table.

(1) Determine HE firing data for the subsequent correction.

(2) Determine APICM data as described in steps c(2) and c(4) above. If an HOB correction is given, go to steps (3) and (4) below.

(3) Correct the ICM fuze setting by using table B of the appropriate ICM tabular firing table addendum.

(a) Enter column 1 with the M564/M582 HE fuze setting.

(b) From column 5, extract the correction for a 50-meter increase in height of burst.

(c) Multiply the factor by the number of 50-meter increments needed.

(d) Apply the HOB correction to the ICM fuze setting that was determined from the ICM fuze setting scale on the GFT corresponding to the HE data for the subsequent correction.

Note. The ICM piece deflection is the HE piece deflection determined for the subsequent correction.

(4) Determine the APICM quadrant elevation to fire by using table A of the appropriate ICM tabular firing table addendum.

(a) Enter column 1 with the HE quadrant elevation to the nearest listed value.

(b) From column 5, determine the correction factor for a 50-meter increase in the height of burst.

(c) Multiply the correction factor by the number of 50-meter increments needed. Express the answer to the nearest mil.

(d) Apply the HOB correction to the APICM quadrant elevation corresponding to the subsequent correction.

Note. Low-level wind corrections are not used when computing data for antipersonnel improved conventional munitions.

9-5. SMOKE PROJECTILES

a. Types.

(1) **Hydrochloroethane.** Hydrochloroethane (HC) smoke projectiles are available for 105-mm and 155-mm howitzers. They are used for screening, spotting, and signaling purposes. The projectile has no casualty-producing effects. This base-ejection projectile is ballistically similar to the HE projectile. It is fitted with a mechanical time fuze M565 or M577. The round expels smoke canisters that emit smoke for 40 to 90 seconds (sec).

(2) **Burster-type white phosphorus.** White phosphorus projectiles are available for 105-mm and 155-mm howitzers. They are burster-type projectiles that can be fired with PD or MT fuzes. The WP projectile has an incendiary effect and is ballistically similar to the HE projectile. Normally, shell WP is employed for this incendiary effect. The projectile can be used also for screening, spotting, and signaling purposes.

(3) **Enhanced smoke-producing white phosphorus.** The M825 WP projectile is an enhanced smoke-producing DPICM round. Employment of the M825 projectile is discussed in paragraph 9-19.

b. Employment. Smoke is employed by use of quick smoke and immediate techniques.

(1) Quick smoke.

(a) A quick smoke mission is fired to build a deliberate smoke screen. The FDC processes the quick smoke mission as shown

in figure 9-10. One, two, or three platoons may fire in effect to screen an area of up to 600 meters. For planning purposes, obscuration time could be maintained from 4 to 15 minutes. The following is a list of quick smoke mission characteristics:

- Delivery technique: Quick smoke (small-area suppression).
- Type of target: Small area of 100 to 600 meters.
- Number of guns: One, two, or three platoons. (Responsiveness dictates that quick smoke missions be fired by platoon.)
- Type of ammunition: HC or WP.
- Sheaf: Parallel.
- Obscuration time: 4 to 15 minutes.
- Command and control: Approval of maneuver battalion commander.

(b) Upon receipt of the call for fire requesting quick smoke, the FDO takes the following actions:

- Uses table 9-2 to determine the number of platoons required to fire the mission. He enters the table with caliber, wind direction, and width of target to be obscured and determines the number of platoons to fire as two.
- Determines the rate of fire and total number of rounds to fire per tube. He enters the appropriate quick smoke table (table 9-3, 9-4, 9-5, or 9-6) with weather conditions (including wind speed determined from the met message or observation), and duration of smoke screen requested by the observer. Weather conditions are explained in table 9-7.
- Issues his fire order.

EXAMPLE:

Weather conditions are observed as favorable with 10-knot winds. The total number of rounds to fire per tube is five, with a rate of fire of one round per minute (min).

Observer <u>H23</u>		CALL FOR FIRE		TGT <u>375</u> GFT <u>R4</u>		Δ PS										
Grid: <u>645365</u>		AP/FF/IS/S		BTRY <u>355</u> DFT <u>L7</u>		100/R <u>20</u>										
Polar: Dir _____ Dis _____ U/D _____ VA _____				<u>V1 + 20</u> <u>L3</u>		/R <u>10</u>										
Shift _____ Dir _____ U/D _____						20/R _____										
SCREEN TREELINE, 500M, CROSSWIND, 7MIB, SMK 1/E				4 Si $\div$ 10		10m Si _____										
FIRE ORDER <u>R AND C (5)</u>		OF Corr <u>L3</u>		Si <u>+4</u>												
INITIAL FIRE COMMANDS		FM ☒ MF <u>RIGHT CENTER ADJ #20</u> Rg <u>5130</u>		Cht Df <u>2469</u>		EI <u>334</u>										
Sp Instr _____		Sh _____ Lot _____ Chg _____ Fz _____ Ti _____		Df _____		QE <u>338</u>										
MTOG, SH SMK, AC 7826		4 T		PEr _____ TF _____		(5) SH SMK LOT HY FZ TI in Eff										
						Ammo Exp <u>(1) Q</u> ☒										
Tgt	Location	Priority	Firing Unit	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	MOB Corr	Si ()	EI	QE	Exp	Type
(Dir) MF SH, Fz	DoV	Og	MOB Corr													
1840	SH SMK			SH SMK LOT HY		(18.9)										
				FZ TI	-20	16.8			(2474)					338	(1)	
	R400-400	1150				(16.8)										
FFE				RIGHTS CTR	-20	(14.6)	2412	L3	(2417)	4630	+10	+14	293	(307)		
				BY RD AMC												
				SPEC CORR												
				RIGHT PLT											(11)	
							PLATOON SPECIAL CORRECTIONS COMPUTED AS SHOWN IN CHAPTER 13								(21) SMK	
				EOM												
TREELINE SCREENED EOM (KNOWN DATA MULTIPLLOT GFT SETTING USED)																
Dtry <u>A</u>	DTG <u>5122/84</u>		Tgt <u>AC7826</u>		Replot Grid _____		Replot Alt _____									

Figure 9-10. Quick smoke mission example.

- Controls the firing of the rounds in accordance with the rate of fire extracted from the quick smoke tables once the unit is in fire-for-effect phase.

(d) The HCO determines and announces chart range and deflection. The VCO determines and announces site.

(e) The computer determines and announces the fire commands for the HE adjustment.

(c) The computer determines and announces initial fire commands.

(f) The observer sends his subsequent corrections.

Table 9-2. Quick smoke planning data.

WEAPON/ AMMUNITION		WIDTH OF TARGET TO BE OBSCURED (METERS)					
		WIND DIRECTION					
		CROSS			HEAD/TAIL		
155 mm	HC	400	500	600	100	200	300
	WP	200	300	400	100	200	300
105 mm	HC	300	400	500	100	200	300
	WP	100	200	300	100	200	300
Platoons to fire		1	2	3	1	2	3

Table 9-3. Quick smoke data—155 mm, shell smoke, fire for effect.

DURATION REQUESTED BY FORWARD OBSERVER (MINUTES)														
WEATHER CONDITION	WIND SPEED (KNOTS)	RATE OF FIRE	4	5	6	7	8	9	10	11	12	13	14	15
FAVORABLE	5	1 RD/2 MIN	2	2	3	3	4	4	5	5	6	6	7	7
	10	1 RD/1 MIN	2	3	4	5	6	7	8	9	10	11	12	13
	15	1 RD/40 SEC	3	4	6	7	9	10	12	13	15	16	18	19
MARGINAL	5	1 RD/40 SEC	3	4	6	7	9	10	12	13	15	16	18	19

Table 9-4. Quick smoke data—155 mm, shell WP, fire for effect.

DURATION REQUESTED BY FORWARD OBSERVER (MINUTES)														
WEATHER CONDITION	WIND SPEED (KNOTS)	RATE OF FIRE	2	3	4	5	6	7	8	9	10	11	12	13
FAVORABLE	5	1 RD/2 MIN	2	3	3	4	4	5	5	6	6	7	7	8
	10	1 RD/30 SEC	4	6	8	10	12	14	16	18	20	22	24	26
	15	1 RD/20 SEC	6	9	12	15	18	21	24	27	30	33	36	39
MARGINAL	5	EXCEEDS RATE OF FIRE												

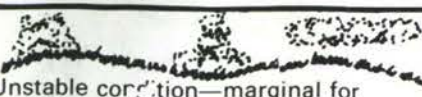
Table 9-5. Quick smoke data—105 mm, shell smoke, fire for effect.

DURATION REQUESTED BY FORWARD OBSERVER (MINUTES)														
WEATHER CONDITIONS	WIND SPEED (KNOTS)	RATE OF FIRE	3	4	5	6	7	8	9	10	11	12	13	14
FAVORABLE	5	1 RD/1 MIN	2	3	4	5	6	7	8	9	10	11	12	13
	10	1 RD/30 SEC	3	5	7	9	11	13	15	17	19	21	23	25
	15	1 RD/24 SEC	4	6	9	11	14	16	19	21	24	26	29	31
MARGINAL	5	1 RD/20 SEC	4	7	10	13	16	19	22	25	28	31	34	37

Table 9-6. Quick smoke data—105 mm, shell WP, fire for effect.

DURATION REQUESTED BY FORWARD OBSERVER (MINUTES)														
WEATHER CONDITIONS	WIND SPEED (KNOTS)	RATE OF FIRE	3	4	5	6	7	8	9	10	11	12	13	14
FAVORABLE	5	1 RD/40 SEC	5	7	8	10	11	13	14	16	17	19	20	22
	10	1 RD/30 SEC	6	8	10	12	14	16	18	20	22	24	26	28
	15	1 RD/15 SEC	11	15	19	23	27	31	35	39	43	47	51	55
MARGINAL	5	EXCEEDS RATE OF FIRE	16	22	28	34	40	46	52	58	64	70	76	82

Table 9-7. General atmospheric conditions and the effects on smoke.

SMOKE CONDITION (TEMPERATURE GRADIENT)	TIME OF DAY WEATHER CONDITIONS	EXPECTED SMOKE BEHAVIOR AS THE SMOKE DRIFTS DOWNWIND. WIND DIRECTION
IDEAL (Inversion)	1. Night—until 1 hour after sunrise. 2. Wind speed less than 5 knots. 3. Sky cover less than 30 percent. ALL THREE CONDITIONS MUST BE MET.	 Stable condition—ideal for smoke employment.
FAVORABLE	This condition occurs most often 1–2 hours before and after sunrise and when the wind speed is 5 knots or more and/or the sky cover is 30 percent or more.	 Neutral condition—favorable for smoke employment.
MARGINAL (Lapse)	1. Day—beginning 2 hours after sunrise. 2. Wind speed less than 5 knots. 3. Sky cover less than 30 percent. ALL THREE CONDITIONS MUST BE MET.	 Unstable condition—marginal for smoke employment.

Note. In the example shell HE did not require adjustment.

(g) The computer announces subsequent fire commands to the adjusting piece. He then determines shell smoke fuze setting by reading the M564 fuze setting under the time gage line and subtracting 2.0 seconds.

(h) The observer spots the round and sends the correction.

(i) The FDO supplements his fire order by saying **BY ROUND AT MY COMMAND, SPECIAL CORRECTIONS BY PLATOON.**

(j) The computer announces the subsequent fire commands: **RIGHT AND**

CENTER 5 ROUNDS, BY ROUND AT MY COMMAND, SPECIAL CORRECTIONS. (See chapter 13 for computation of special corrections.)

(2) Immediate smoke.

(a) An immediate smoke mission may be fired as a separate mission or as a followup to immediate suppression. The FDC processes the immediate smoke mission as shown in figure 9-11. Immediate smoke missions normally are fired by a two-gun platoon. One gun fires shell WP, fuze quick, and the other gun fires shell HC smoke, fuze time, on the first volley. If additional volleys are fired, both guns will fire shell HC smoke, fuze time. When firing the M825 smoke round, both guns will fire the M825 projectile for the initial and any subsequent volleys. Unit SOP should detail the number of volleys and

[illegible]

Figure 9-11. Example of an immediate smoke mission.

dictate which gun will fire the WP and which will fire smoke, if applicable, for these missions. The following is a list of immediate smoke mission characteristics:

- Delivery technique: Immediate smoke (point suppression). The immediate smoke technique can be used in an immediate suppression mission on a target of opportunity by unit SOP. A mix of WP and HC normally will follow the initial suppression rounds when immediate smoke is requested.
- Type of target: Point or small area of 150 meters or less.
- Number of guns: One platoon (two guns). Responsiveness dictates that immediate smoke missions be fired by platoon.
- Type of ammunition: First rounds, WP or HC; second rounds, HC; or all rounds, M825 smoke.
- Sheaf: Platoon center to target center.
- Obscuration time: Thirty seconds to five minutes.
- Command and control: By SOP and/or approval of maneuver company commander.

Note. Because speed is of the utmost importance in an immediate type mission, the hasty correction tables, while valid, may be time consuming. Therefore, the immediate smoke procedures call for use of the alternate special correction method of determining chart data from a plotted platoon location on the firing chart. This method negates the need for any platoon corrections.

(b) Upon receipt of the call for fire, the FDO determines and issues the fire order.

(c) The computer sends initial fire commands.

(d) The HCO determines and announces chart range and deflection from the platoon location on the firing chart. The VCO determines and announces average site.

(e) The computer sets the announced range under the MHL for the appropriate charge on the GFT. He determines the shell

HC fuze setting by reading the M564 fuze setting under the time gage line and subtracting 2.0 seconds. He does not determine a fuze setting for the WP round, because it is fired with a PD fuze.

(f) The computer determines deflection to fire for both rounds by adding the total deflection correction to the announced chart deflection.

(g) The computer determines quadrant elevation for both rounds by reading elevation under the appropriate gage line and applies the announced average site. He ignores any corrections for projectile weight differences.

(h) Fire commands are continued in the normal manner.

(i) In anticipation of subsequent corrections, the HCO/VCO places the grid over the initial target location and orients the target grid in the appropriate direction. After receiving the correction, he plots the correction and announces new chart data. The computer then computes data and announces fire commands as described above.

(3) **Computer procedures for immediate smoke.** Data are computed for an immediate smoke mission by determining shell HE/fuze Q data. The same deflection and quadrant are fired for both WP and smoke. The time settings for the smoke rounds are determined by subtracting 2.0 from the displayed time of flight.

9-6. ILLUMINATING PROJECTILES

a. Illuminating projectiles are available for the 105-mm and the 155-mm howitzers. They are used for illuminating a designated area for observing enemy night operations, for adjusting artillery fires at night, for marking locations, or in G/VLLD missions.

b. Illuminating projectiles are base-ejection projectiles fired with MT fuzes. The filler consists of an illuminating canister and a parachute assembly. The two models of illuminating projectiles for the 105-mm howitzer are the M314A2 and the newer M314A3 that has a slightly longer burning time. The 155-mm system also has two

illuminating models. These models are the M118 and the newer M485A2 that has a significant increase in illumination time.

c. Illumination is conducted by use of the following techniques:

(1) The one-gun illumination pattern is used when effective illumination can be accomplished by firing one round at a time.

(2) The two-gun illumination pattern is used when an area requires more illumination than can be furnished by one gun.

(a) The two-gun illumination range spread pattern is used when the area to be illuminated has greater depth than width (fired parallel to the line of fire).

(b) The two-gun illumination lateral spread pattern is used when the area to be illuminated has greater width than depth (fired perpendicular to the line of fire).

(3) The four-gun illumination pattern is used to illuminate a large area. Four rounds are fired simultaneously by using both the lateral and the range spread patterns.

9-7. ILLUMINATING PROJECTILE MANUAL PROCEDURES

There are two manual methods that may be used for computing data for the illuminating round. One method uses a special illuminating projectile GFT, and the other method uses part 2 of the base HE tabular firing table.

a. *Illuminating GFT.* Graphical firing tables have been developed for use with all 155-mm M485 illuminating projectiles and with the 105-mm M314 and M314A2E1 projectiles. Figure 9-12 shows an illuminating graphical firing table. The scales on the illuminating GFT, from top to bottom, are as follows:

(1) 100/R scale. The 100/R scale denotes the number of mils necessary to shift the burst 100 meters laterally for a given range. 100/R is read to the nearest 1 mil.

(2) Range scale. The range scale is the base scale on the graphical firing table. All other scales are plotted with reference to it. Range is read to the nearest 10 meters.

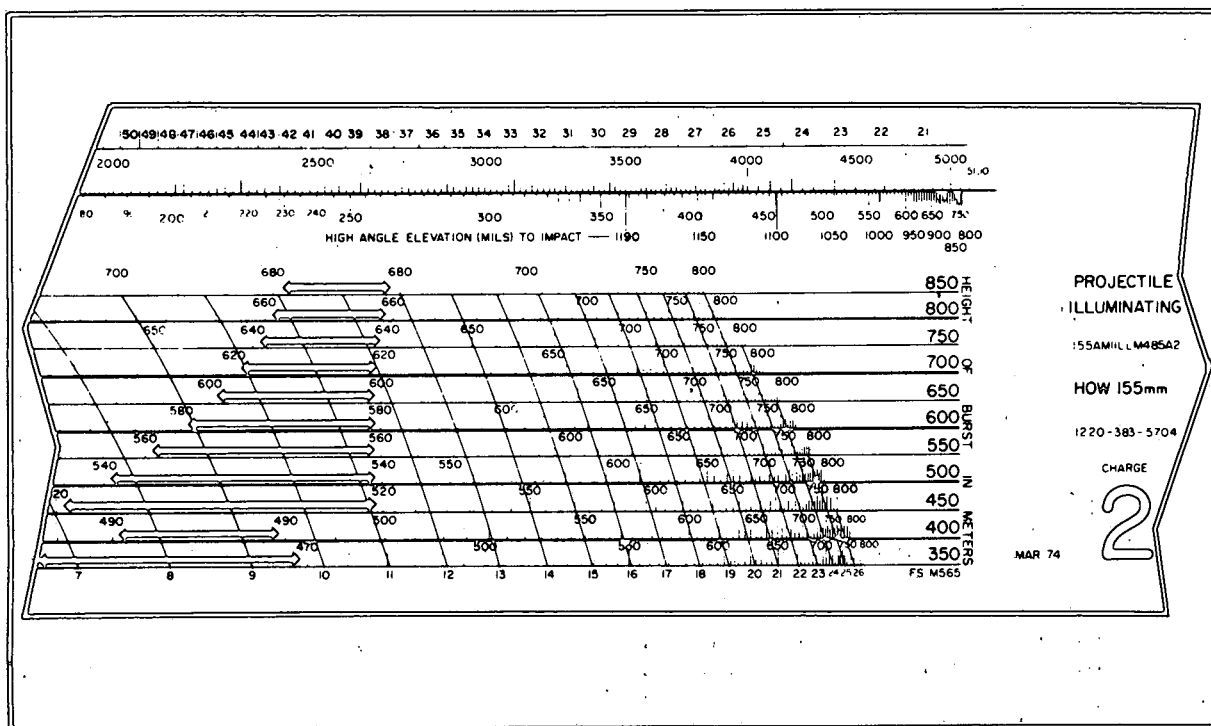


Figure 9-12. Illuminating graphical firing table.

(3) Elevation-to-impact scale. The elevation-to-impact scale is graduated in mils. Low-angle elevation increases from left to right and is read to the nearest 1 mil. High-angle elevation increases from right to left and is printed in red. The elevation-to-impact scale is used to determine the range (on the range scale) to which a nonfunctioning projectile will travel.

(4) Height-of-burst scale. The height-of-burst scale is labeled at the left and right of the main body of each set of scales. These scales are graduated in 50-meter increments. They extend from 350 meters to 850 meters.

(5) **Quadrant elevation scale.** The QE scale indicated for each listed height of burst gives the quadrant elevation to achieve the height of burst and the desired range. The QE scale is graduated in mils and is visually interpolated to the nearest 1 mil.

(6) Fuze setting scale. The FS scale consists of a red line for each whole fuze setting increment for the MT fuze. The value of each line is printed in red at the bottom of the scale. The fuze setting is read for the desired range and height of burst to an accuracy of 0.1 fuze setting increment by visual interpolation.

b. Charge Selection. The FDO selects the charge to fire. He should select the lowest practical charge to prevent a malfunction caused by the parachute ripping when the flare is ejected from the projectile.

c. One-Gun Illumination Mission. An example of a one-gun illumination mission is shown in figure 9-13. The manual FDC processes the mission by use of the GFT in the following manner:

(1) Upon receipt of the observer's call for fire, the FDO analyzes the target and issues his fire order. The RATELO composes and transmits the message to observer.

(2) The computer determines and sends initial fire commands to the firing battery.

(3) The HCO plots the target and announces chart data to the computer.

(4) The VCO determines and announces the vertical interval between the battery and the target area to be illuminated. The computer lists the information on the record of fire. The vertical interval is expressed to the nearest 50 meters.

(5) The computer records the chart deflection on the record of fire as the deflection to fire. No deflection correction is applied.

CALL FOR FIRE Observer <u>H23</u> AF/PFE/PS/S _____ Tgt _____ Grid: <u>632 368</u> Polar: Dir _____ Dis _____ U/D _____ VA _____ Shift _____ Dir _____ U/R _____ U/D _____ <u>SUSPECTED VEHICLE CONVOY, ILLUM</u>										TGT 370 BTRY 355 <u>VI +15 ≈ 0</u> 600 + 0 HOB 600										△ PS 100/R <u>25</u> /R 20/R <u>5</u> HOB Corr Si _____ Ei <u>438</u> Qi <u>438</u>																																																																				
FIRE ORDER *3, ① INITIAL FIRE COMMANDS FM MF #3 ① Rg <u>4040</u> Sp Instr _____ Sh ILL Lot LY Chg 14 Fz TI Ti 12.8 Dt <u>2683</u> MTO A AC7810 4 Y PER _____ TF _____ in Eff _____ Ammo Exp ① ILLUM										Dt Corr _____ Chg Dt <u>2683</u> Ei <u>438</u> Qi <u>438</u>																																																																														
<table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th>Tgt</th> <th>Location</th> <th>Priority</th> <th>Firing Unit</th> <th colspan="12">SUBSEQUENT FIRE COMMANDS</th> <th>Exp</th> <th>Type</th> </tr> <tr> <th>Dir, MF Sh, Fz</th> <th>Dev</th> <th>Rg</th> <th>HOB Corr</th> <th>MF, Sh, Chg, Fz</th> <th>FS Corr</th> <th>TI</th> <th>Chart Dt</th> <th>Df Corr ()</th> <th>Df Fired</th> <th>Chart Rg</th> <th>HOB Corr</th> <th>Si ()</th> <th>Ei</th> <th>Qi</th> <th>Exp</th> <th>Type</th> </tr> </thead> <tbody> <tr> <td>EOM</td> <td>NOTHING</td> <td>EM</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td>OBSERVED</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>										Tgt	Location	Priority	Firing Unit	SUBSEQUENT FIRE COMMANDS												Exp	Type	Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	TI	Chart Dt	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si ()	Ei	Qi	Exp	Type	EOM	NOTHING	EM																OBSERVED																									
Tgt	Location	Priority	Firing Unit	SUBSEQUENT FIRE COMMANDS												Exp	Type																																																																							
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	TI	Chart Dt	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si ()	Ei	Qi	Exp	Type																																																																								
EOM	NOTHING	EM																																																																																						
	OBSERVED																																																																																							
Btry _____ DTG <u>5/22/84</u> Tgt <u>AC7810</u> Replot Grid _____ Replot Alt _____																																																																																								

Figure 9-13. Example of a one-gun illumination mission.

(6) The computer determines and records the fuze setting and quadrant elevation to fire. He places the MHL over the announced chart range and determines the data from the appropriate height-of-burst scale.

(7) The computer completes and announces the fire commands.

(8) When direction is announced by the forward observer, the chart operators prepare for subsequent corrections by orienting the target grid in the normal manner.

d. Illumination Range Spread Firing Data. When the observer requests a range spread, the platoon closest to the battery center should fire the mission. A value of 500 meters (400 meters for 105-mm weapons) is added to chart range, and fuze setting and quadrant are determined for one gun. A value of 500 meters is then subtracted from the chart range to determine fuze setting and quadrant for the other gun. Both guns fire chart deflection (fig 9-14).

e. Illumination Lateral Spread Firing Data. If weapons in the battery are spread far enough apart laterally, firing data based on chart data from battery center can

be used without modification to achieve a lateral spread. The optimum spread for 155-mm illuminating rounds is 1,000 meters. The optimum spread for 105-mm illuminating rounds is 800 meters. If modification to deflection is necessary, 100/R may be applied to achieve the desired spread (fig 9-15).

f. Range and Lateral Spread Firing Data. To produce a range and lateral spread, a combination of the above procedures may be used to determine firing data for four guns (fig 9-16).

(1) When the vertical interval is 0 meters, the 155-mm M485 illuminating round has a 600-meter optimum height of burst. All other illuminating rounds have a 750-meter optimum height of burst. The computer modifies the optimum height of burst by adding the value of the vertical interval, expressed to the nearest 50 meters. The result is the appropriate height-of-burst scale value.

(2) Using the 600-meter height-of-burst scale on the GFT and the announced chart range of 4,030 meters, the computer determines the fuze setting (12.8) and the quadrant elevation (438) to fire.

Observer B6H23		CALL FOR FIRE (A) FFE/IS/S		Tgt		ALT TGT 435		△ PS	
Grid: 636361						ALT BTRY 355		100/R	
Polar: Dir		Dis		U/D		VA		/R	
Shift		Dir		L/R		U/D		20/R	
SUSPECTED PERSONNEL MOVEMENT, ILLUM, RANGE SPREAD						HOB Scale 600		HOB Corr	
FIRE ORDER #5 & #6 (1)						Df Corr		Si	
INITIAL FIRE COMMANDS ✓ FM MF #5 & #6 ADJ #5460						Rg 4290 (Till. 8)		Cht Df 2577	
Sp Instr AMC SPEC CORR						Sh ILL		Lot LY	
MTO A, TGT AC 7819						PFR		TF	
Tgt						Location		Priority	
Dir, MF						Dev		Rg	
Sh, Fz						MOB Corr		MF, Sh, Chg, Fz	
						FS Corr		Ti	
						Chart Df		Df Corr	
						Df Fired		Chart Rg	
						MOB Corr		Si	
						EI		QE	
						Exp		Type	
						EM		EM	
NOTHING SEEN									
Dtry A		DTG 5/22/84		Tgt AC 7819		Replot Grid		Replot Alt	

Figure 9-14. Record of fire—range spread illumination mission.

Observer: B6H23		CALL FOR FIRE		Tgt: _____		TGT 375 600		△ FS								
Grid: 636368		AF/FFE/IS/S		Tgt: _____		BTRY 355 + 0		100/R 21								
Polar: Dir _____		Dis _____		U/D _____		VI + 20 = 0 600M		/R 105								
Shift: _____		Dir _____		U/R _____		U/D _____		20/R								
SUSPECTED VEHICLE MOVEMENT ILLUM LAT SPREAD						Si ÷ 10		10m Si								
FIRE ORDER						Df Corr R105/L105		SI								
INITIAL FIRE COMMANDS						✓ FM MF *1/2 ADJ, *1/2 ① Rg 4880		Cht Df 2655								
Sp Instr AMC, SPECIAL CORR						Sh ILL Lot LY Chg 4 Fz Ti 165		Df 2550/2760								
MTO A AC 7812						T		PEg TF in Eff Ammo Exp ② ILLUM								
Tgt	Location	Priority	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si ()	EI	QE	Exp	Type
				*1 DF												
				*2 DF												
EM - NOTHING OBSERVED EM																
Btry A		DTG		Tgt AC 7812		Replot Grid		Replot Alt								

Figure 9-15. Record of fire—lateral spread illumination mission.

Observer: B6H23		CALL FOR FIRE		Tgt: _____		TGT 375 600		△ FS								
Grid: G31582		AF/FFE/IS/S		Tgt: _____		BTRY 355 + 0		100/R 17								
Polar: Dir _____		Dis _____		U/D _____		VI + 20 = 0 600M		500/R 85								
Shift: _____		Dir _____		U/R _____		U/D _____		20/R								
SUSPECTED TANK CO ILLUM RG + LAT SPREAD						Si ÷ 10		10m Si								
FIRE ORDER LEFT + RIGHT ADJ ①						Df Corr		SI								
INITIAL FIRE COMMANDS						✓ FM MF LAT + RIGHT ADJ ① Rg 6000		Cht Df 2842								
Sp Instr AMC SPEC CORR						Sh ILL Lot LY Chg 4 Fz Ti		Df								
MTO A AC 7813						T		PEg TF in Eff Ammo Exp								
Tgt	Location	Priority	Firing Unit	SUBSEQUENT FIRE COMMANDS												
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si ()	EI	QE	Exp	Type
#1 RG 6000				QE 54.3						#5 RG (6000) - 500				5500		
				Ti 22.2										QE 51.7		
				DF (2842+85) 2757										Ti 19.6		
														DF 2842		
#2 RG (6000+500)				6500						#6 RG 6000				QE 54.3		
				QE 39.2										Ti 22.2		
				Ti 23.5										DF (2842+85) 2727		
				DF 2842												
				EOM												
EOM NOTHING OBSERVED																
Btry A		DTG 5/22/84		Tgt AC 7813		Replot Grid		Replot Alt								

Figure 9-16. Record of fire—range and lateral spread illumination mission.

Section II

DUAL-PURPOSE IMPROVED CONVENTIONAL MUNITIONS

Table 9-8. DPICM/FASCAM projectiles.

	DPICM	
WEAPON 155 mm 203 mm	PROJECTILE M483A1 M509E1	NUMBER OF SUBMUNITIONS 88 (64 M42s, 24 M46s) 195 M42s
	FASCAM ADAM	
WEAPON 155 mm	PROJECTILE M692/M731	NUMBER OF MINES 36
	RAAMS	
WEAPON 155 mm	PROJECTILE M718/M741	NUMBER OF MINES 9

9-8. CHARACTERISTICS

Dual-purpose improved conventional munitions and the family of scatterable mines (FASCAM) are base-ejection, payload-carrying rounds. They are fired with MT fuzes (M577 or M724) and are filled with a number of submunitions. During flight, the base of the projectile is blown off, and the submunitions are scattered about the target area. Table 9-8 shows the number and type of submunitions in the DPICM/FASCAM rounds. The M825 enhanced smoke round is another DPICM projectile.

capable of fragmentation for incapacitating personnel. The M577 MT fuze is preset to function over the target area and initiate the expulsion charge. The expulsion charge pushes the grenades out of the container and onto the target area. The projectile can be modified for the self-registration mode. The self-registration mode causes the round to point detonate so as to be visible to the observer and destroy the submunitions. It also may produce an airburst for conducting high-burst registrations.

9-9. DPICM PROJECTILES

The DPICM projectiles contain two types of dual-purpose grenades. Both types are capable of penetrating more than 2.5 inches of rolled homogeneous armor. They are also

9-10. DPICM COMPUTATIONS BY USE OF THE GFT AND TFT

Dual-purpose improved conventional munitions procedures for using of the GFT and TFT are as follows:

a. Upon receipt of a call for fire, the FDO analyzes the target and announces his fire order. Figure 9-17 shows a record of fire for a DPICM mission.

Note. The GFT setting in effect is GFT A: Chg 4, Lot 1Y, Rg 6080, El 460, Ti 25.5; GFT Df Corr: R2, Tot Df Corr: L9. A GFT setting for the M483A1 projectile can be determined by firing any method of registration (precision, high burst, abbreviated) or by deriving a GFT setting by use of the met + VE technique. The met + VE technique, using FT l55-AN-1, is the preferred method because of the high cost of firing a DPICM registration.

RECORD OF FIRE																							
Observer <u>B6H23</u>		CALL FOR FIRE		Tgt		TGT 2.4		GFT R2		Δ FS		100/R 25											
Grid: <u>609366</u>		AMFFTS/S				BTRY 355		DFT L5				/R											
Polar: Dir		Dis		U/D		VA						20/R 5											
Shift		Dir		L/R		U/D						HOB Corr											
MECH INF CO, ASSEMBLY AREA, ICM										Si ÷ 10		10m Si											
FIRE ORDER (6), AMC										Df Corr L3		Si -16											
INITIAL FIRE COMMANDS										FM		MF BTRY (6)		Rg		Chf Df 3254		El 271/255					
Sp Instr SPECIAL CORRECTIONS, AMC										Sh		Lot 1Y		Chg 4		Fz		Ti (N.Y)		Df (3257)		Qt (312)	
INTO G(6), AC 7816										T		PER		TF		in Eff		Ammo Exp					
Tgt	Location	Priority	Firing Unit	MF, Sh, Chg, Fz	PS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si ()	El	Qt	Exp	Type							
				LEFT PLT											(12)								
				CTR PLT											(24)								
				RIGHT PLT											(36)								
5820	W400+200W100					(16.2)	3297	L3	(3300)	4270		-16	282	(266)									
RPT						(15.0)			(3300)					(320)									
						+0.2 (15.2)			(3300)		128			(349)									
				LEFT PLT											(48)								
				CTR PLT											(60)								
				RIGHT PLT											(72)	DPICM							
EM, PLT DSP, EST 25 CAS TO GUNS → EM TAB B: +0.0 TAB A + 140																							
GFT SETTING: GFT A, CHG 4, LOT Y, RG 6080, EL 460, TI 25.5																							
$\begin{array}{r} \text{GFT} + 0.0 \\ \text{R2} \end{array}$																							
$\begin{array}{r} \text{TAB B:} + 0.0 \\ \times 2 \\ \hline \text{GFT} + 0.0 \\ \text{R2} \end{array}$																							
$\begin{array}{r} \text{TAB A} + 140 \\ \times 2 \text{ TGT L9} \\ \hline 28.0 \end{array}$																							
Btry A		DTG 5/22/84 1400		Tgt AC 7816		Replot Grid		Replot Alt															
DA FORM 4504 1 OCT 78		REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE										FOR USE OF THIS FORM, SEE FM 6-40; THE PROponent AGENCY IS TRADOC											

Figure 9-17. Record of fire—DPICM mission.

b. The RATELO announces the message to observer.

c. The HCO determines and announces chart data.

d. The computer announces initial fire commands; places the MHL over the announced range; and determines and records elevation, drift, and the M577 fuze setting from the appropriate gage line on the base scale. The elevation and fuze setting determined are for 0 meters height of burst (graze-burst data).

e. The computer then determines the graze-burst quadrant by algebraically adding the announced site to elevation.

f. The computer now applies ballistic corrections to graze-burst data. Ballistic corrections can be applied by use of FT 155-ADD-J-1 or the graphical firing table.

(1) Tabular firing table addendum method. The computer enters the J-1 addendum with the appropriate charge and extracts the ballistic corrections to apply to quadrant. He enters column 1 of table A with the nearest listed value to the graze-burst quadrant determined in paragraph **d** above. He extracts the ballistic correction from column 2 and algebraically adds the ballistic correction to the graze-burst quadrant elevation. He then enters table B to determine the ballistic correction to the fuze setting. He enters column 1 with the graze-burst time determined in paragraph **d** above. He extracts the correction to the fuze setting from column 2 and algebraically adds the correction to the self-registering time.

(2) Graphical firing table method. The computer determines dual-purpose time by placing the MHL over the M577 graze-burst time, determined in paragraph **d** above, on the M577 graze-burst time scale. Without moving the MHL, read up to the fuze scale labeled ICM M483A1, and read the dual-purpose fuze setting from the manufacturer's hairline.

Note. Minor differences (± 0.2 fuze setting increment) between TFT and GFT data are acceptable.

g. The computer now determines the dual-purpose quadrant by placing the MHL

over the graze-burst quadrant, determined in paragraph **e** above, on the graze-burst elevation scale. Without moving the MHL, read up to the elevation scale labeled ICM M483A1, and read the dual-purpose quadrant from the manufacturer's hairline.

Note. The dual-purpose ICM and FASCAM quadrant scales on the 155AN1M483A1 are mislabeled EL rather than QE.

h. The computer determines the deflection to fire.

i. Next, the computer may apply platoon special corrections (procedures are shown in chapter 13), and he announces firing data to each platoon.

j. When all gun sections announce READY, the FDO gives the command to fire.

k. If the observer sends the subsequent correction that includes a height-of-burst correction, the HCO orients the target grid, plots the deviation and range correction, and announces chart data.

l. The computer determines graze-burst data as described in paragraph **d** above.

m. To derive dual-purpose data, the computer then applies ballistic corrections to the graze-burst data. Ballistic corrections may be applied by use of the TFT addendum or the graphical firing table.

n. To compensate for the 100-meter height-of-burst correction, the computer now determines ballistic corrections. These corrections must be found in the TFT addendum, because the GFT does not list height-of-burst corrections. Corrections are determined for both quadrant and fuze setting.

o. The computer determines quadrant corrections by entering table A with the graze-burst quadrant, determined in paragraph **e** above, and extracting the correction factor from column 3. The value extracted from column 3 is for a 50-meter increase in height of burst. In this example, the correction required by the observer calls

for a 100-meter increase in height of burst. Therefore, the value in column 3 must be multiplied by 2. The resulting value will then be algebraically added to the dual-purpose quadrant determined in paragraph *m* above.

p. The computer determines fuze corrections by entering table B with the graze-burst fuze setting, determined in paragraph *e* above, and extracting the correction factor from column 3. The value extracted from column 3 is for a 50-meter increase in height of burst. The correction required by the observer was for a 100-meter increase in height of burst. Therefore, the value in column 3 must be multiplied by 2. The resulting value will be algebraically added to the dual-purpose time determined in paragraph *m* above.

q. The fire-for-effect data represent a center-of-battery to center-of-target solution. Special corrections for each platoon may be applied on the basis of the procedures in chapter 13.

r. The corrected FFE data are announced.

s. When all sections report READY, the FDO commands FIRE.

t. The observer sends END OF MISSION, PLATOON DISPLACING, ESTIMATE 25 CASUALTIES, OVER.

u. END OF MISSION is reported to the gun sections.

9-11. COMPUTER PROCEDURES FOR DPICM

See the appropriate job aids for computer procedures for dual-purpose improved conventional munitions.

9-12. FASCAM PROJECTILES

a. The purpose of FASCAM projectiles is to delay, disrupt, destroy, and disorganize enemy forces by emplacing the artillery-delivered minefield.

b. The two types of FASCAM projectiles are area denial artillery munitions (ADAM) and remote antiarmor mine system (RAAMS).

(1) ADAM. The ADAM projectile is used to deny the enemy the use of certain terrain areas. Each mine arms itself after it comes to rest on the ground. Individual trip wires are extended from each mine. The trip wire activates the explosive when disturbed by movement. The minefield will self-destruct after a preset period of time. The preset time is determined by the model number of the round.

(2) RAAMS. The RAAMS projectile is effective against armored vehicles. The mines become armed within a few seconds after landing. Any metallic object passing near the mines will cause them to activate and damage or destroy the object. Some of the mines have an antisturbance firing mechanism. It will activate the mine if disturbed by minefield clearance operations. If, after a certain period of time (short self-destruct [SD] for less than 24 hours; long SD for more than 24 hours), the mines have not been activated, they are destroyed by a self-contained destruction mechanism.

c. Normally, 155-mm field artillery units carry short SD ADAM/RAAMS as part of their basic load. Long SD ADAM/RAAMS are used primarily for planned minefields in support of barrier/obstacle plans. Such use allows for advance logistical coordination to stockpile long SD ADAM/RAAMS projectiles.

d. The field artillery has three roles in the use of scatterable mines.

(1) It is a delivery system for planned minefields to support the barrier/obstacle plan.

(2) It may use scatterable mines to establish a minefield in front of or on top of targets of opportunity.

(3) It may deliver scatterable mines as a harassing agent in conjunction with other munitions, such as DPICM, HE, and smoke, during the attack of any target. Use of FA-delivered mines in any capacity requires detailed coordination among the G3/S3, the

engineer officer, and the fire support coordinator.

9-13. FASCAM EMPLOYMENT

Upon receipt of a planned FA-delivered minefield mission, the FDC determines data on the basis of registration corrections determined from the M483A1 (DPICM) registration. Then, ballistic corrections are applied for either shell M718/M741 (RAAMS) or shell M692/M731 (ADAM). Normally, the emplacement of a tactical minefield is a fire-for-effect mission. When verification of a location is needed, a forward observer may adjust a tactical minefield.

9-14. FASCAM COMPUTATIONS

The following are procedures to emplace a planned minefield by use of the GFT and TFT. Upon receipt of DA Form 5032-R (Field Artillery Delivered Minefield Planning Sheet) (fig 9-18), the FDO inspects sections A, B, and C.

a. Section A has been completed by the fire support coordinator at the requesting unit. It identifies basic information about the mission necessary for issuing a fire order and computing data for a mission.

b. Section B has been completed by the G3/S3/engineer. It includes remarks relative to the mission.

c. Section C has been completed by the fire support element (FSE)/FSO. It includes remarks relative to the mission.

d. Section D will be completed by the FDO. It will help him emplace the minefield.

(1) For planned minefields, the target number is the same as that in section A, block 1. Unplanned minefields are given a target number by the field artillery firing unit. If the target is preplanned, the FDO fills in section D, block 22, with the target number from section A, block 1 (fig 9-18).

(2) The unit emplacing the minefield is entered in section D, block 23 (fig 9-18).

(3) The HCO plots the minefield end points, determines the minefield center, and determines the range and deflection from the battery to the minefield center. The range from the firing unit to the minefield center is entered in section D, block 24 (fig 9-18). Range is necessary when computing the safety zone and when determining the number of aimpoints needed to emplace the minefields.

(4) Use of high- or low-angle fire to emplace the minefield is indicated by an X in the appropriate box (section D, block 25) corresponding to mines emplaced (ADAM/RAAMS). The angle of fire is necessary for computing the safety zone and the number of aimpoints necessary to emplace the minefield. The ADAM/RAAMS minefield is based on a 400- by 400-meter planning module except when RAAMS is delivered by low-angle fire. In that case, a 200- by 200-meter module is used. Therefore, the FDO considers this when determining the delivery technique to provide the minefield depth required (fig 9-18). Referring to information in section A, block 5, and cross-referencing that information with the size of the minefield planning modules, the FDO determines the type of trajectory he will fire in the mission.

(5) The delivery technique used is indicated in the appropriate location in block 26 (fig 9-18). Determination of the delivery technique is necessary for computing the safety zone and for selecting the number of aimpoints necessary to emplace the minefield. The FDO selects the delivery technique on the basis of the location of the target. Transfer is used if the minefield is within the current GFT transfer limits. If the minefield is outside the current GFT transfer limits, the met + VE delivery method is used.

(6) Aimpoints are placed in section D, block 27 (fig 9-18). If there is just one aimpoint, the coordinates are entered in the FROM space and NA is entered in the TO space. The determination of individual aimpoints is discussed in paragraph 9-15.

(7) Section D, block 28, is used for the date-time group of the mission. This is the time that emplacement of the minefield is completed (time of impact of last mines fired).

FIELD ARTILLERY DELIVERED MINEFIELD PLANNING SHEET			
For use of this form see TC 6 20 5 The proponent agency is TRADOC			
SECTION A MINEFIELD DATA			
1 TARGET NUMBER AC7821	2 PRIORITY	3 REQUESTER DIVISION G3	
4 MINEFIELD END POINTS (COORDINATES) FROM 6313 3800 ALTITUDE 0330 LENGTH 200M			
5 MINEFIELD DEPTH NA		6 MINEFIELD WIDTH NA	
7 ADAM (APERS) DENSITY 0.001		8 RAAMS (AT) DENSITY	
9 SELF DESTRUCT TIME SHORT ☒ LONG ☐		10 SCHEDULED MINEFIELD HRS MIN ON CALL ☒	
11 CAUTION NLT EMPLACEMENT TIME	12 APPROVAL AUTHORITY CG DIVISION	13 DATE TIME GROUP (DTG) DTG	
14 REMARKS PER REQUEST 1ST BDE			
SECTION B G3/S3/ENGR			
15 DTG RECEIVED DTG		16 DTG SAFETY ZONE DISSEMINATED DTG	
17 REMARKS			
SECTION C FSE FSO			
18 DTG TO UNIT 5/22/84 1400	19 DTG FROM UNIT 5/22/84 1402	20 DTG TO G3 S3 ENGR 5/22/84 1405	
21 REMARKS			
SECTION D FDC DATA			
22 TARGET NUMBER AC7821	23 FIRING UNIT A	24 RANGE TO MINEFIELD CENTER 5830	
25 TRAJECTORY ADAM ☐ HIGH ☒ LOW RAAMS ☐ HIGH ☐ LOW		26 DELIVERY TECHNIQUE MET - VE TRANSFER ☒ OBSERVER ADJUST ☐	
27 AIMPOINT COORDINATES (LEFT AND RIGHT OR SINGLE) ADAM FROM 6313 TO 3000 HAAMS FROM TO			
28 DTG MISSION COMPLETED 5/22/84 1500			
29 REMARKS			
DA Form 5032-R, Jan 82			

Figure 9-18. Field artillery delivered minefield planning sheet.

9-15. AIMPOINT SELECTION TABLES

The aimpoint selection tables are used to determine the number of aimpoints required to ensure the emplacement of a given size minefield as indicated by the field artillery delivered minefield planning sheet.

a. To select the proper table, the FDC must determine the following:

(1) From the field artillery delivered minefield planning sheet, determine delivery technique (transfer, met + VE, or observer adjust), shell (M718/741 [RAAMS] or M692/731 [ADAM]), and trajectory (low- or high-angle fire).

(2) From the firing chart, determine the battery-minefield angle. The battery-minefield angle (BMA) is the smaller angle formed by the intersection of the minefield centerline with a line drawn from the battery center to the center point of the minefield. For example, the FDO inspects the firing chart and determines that the battery-minefield angle is greater than 800 mils.

b. Each table is constructed to coincide with a particular set of parameters as defined above. Use the matrix key (table 9-9) to determine the minefield employment table to be used. Enter the matrix key from the left with the appropriate delivery technique, shell, trajectory, and battery-minefield

Table 9-9. Matrix key to field artillery delivered scatterable mine employment.

TABLE	1	2	3	4	5	6	7	8
TRANSFER/MET + VE	X	X	X	X				
OBSERVER ADJUST					X	X	X	X
M718/741 (RAAMS) LOW ANGLE	X	X			X	X		
M718/741 (RAAMS) HIGH ANGLE			X	X			X	X
M692/731 (ADAM) LOW/HIGH ANGLE			X	X			X	X
BMA $\leq$ 800 MILS	X		X		X		X	
BMA $\geq$ 800 MILS		X		X		X		X

Table 9-10. Mine employment table 1.

Delivery Technique: Transfer or met + VE											
Shell: M718/741 (RAAMS)											
Trajectory: Low angle											
BMA: Equal to or less than 800 mils											
RANGE (METERS)	DESIRED MINEFIELD WIDTH (METERS)										
	100	200	300	400	500	600	700	800	900	1,000	
	4,000	2	3	3	4	4	5	5	6	6	7
	6,000	2	3	3	4	4	5	5	6	6	7
	8,000	2	3	3	4	4	5	5	6	6	7
	10,000	3	3	4	4	5	5	6	6	7	7
	12,000	3	4	4	5	5	6	6	7	7	8
	14,000	4	4	5	5	6	6	7	7	8	8
	16,000	4	4	5	5	6	6	7	7	8	8
	17,500	4	5	5	6	6	7	7	8	8	9

angle. For example, the FDO enters the matrix with met + VE, M692/731 ADAM low/high angle, and a BMA greater than 800 mils and extracts table 4.

c. Enter table 4 with the range to the minefield center (expressed to the nearest 2,000 meters [if exactly halfway between, express to lower range]) and the desired width of the minefield. Extract from the table the number of aimpoints required to emplace the minefield.

Table 9-11. Mine employment table 2.

Delivery Technique: Transfer or met + VE Shell: M718/741 (RAAMS) Trajectory: Low angle BMA: Greater than 800 mils											
RANGE (METERS)	DESIRED MINEFIELD WIDTH (METERS)										
		100	200	300	400	500	600	700	800	900	1,000
	4,000	1	2	2	3	3	4	4	5	5	6
	6,000	1	2	2	3	3	4	4	5	5	6
	8,000	1	2	2	3	3	4	4	5	5	6
	10,000	2	2	3	3	4	4	5	5	6	6
	12,000	2	3	3	4	4	5	5	6	6	7
	14,000	2	3	3	4	4	5	5	6	6	7
	16,000	3	3	4	4	5	5	6	6	7	7
	17,500	3	3	4	4	5	5	6	6	7	7

Table 9-12. Mine employment table 3.

Delivery Technique: Transfer or met + VE

Shell: M692/731 (ADAM)
M718/741 (RAAMS)

Trajectory: Low angle or high angle (ADAM)
High angle (RAAMS)

BMA: Equal to or less than 800 mils

RANGE (METERS)	DESIRED MINEFIELD WIDTH (METERS)										
	100	200	300	400	500	600	700	800	900	1,000	
	4,000	1	2	2	2	2	3	3	3	3	4
	6,000	1	2	2	2	2	3	3	3	3	4
	8,000	1	2	2	2	2	3	3	3	3	4
	10,000	2	2	2	2	3	3	3	3	4	4
	12,000	2	2	2	3	3	3	3	4	4	4
	14,000	2	2	3	3	3	3	4	4	4	4
	16,000	2	2	3	3	3	3	4	4	4	4
	17,500	2	3	3	3	3	4	4	4	4	5

Table 9-13. Mine employment table 4.

Delivery Technique: Transfer or met + VE Shell: M692/731 (ADAM) M718/741 (RAAMS) Trajectory: Low angle or high angle (ADAM) High angle (RAAMS) BMA: Greater than 800 mils										
RANGE (METERS)	DESIRED MINEFIELD WIDTH (METERS)									
	100	200	300	400	500	600	700	800	900	1,000
4,000	1	1	1	2	2	2	2	3	3	3
6,000	1	1	1	2	2	2	2	3	3	3
8,000	1	1	1	2	2	2	2	3	3	3
10,000	1	1	2	2	2	2	3	3	3	3
12,000	1	2	2	2	2	3	3	3	3	4
14,000	1	2	2	2	2	3	3	3	3	4
16,000	2	2	2	2	3	3	3	3	4	4
17,500	2	2	2	2	3	3	3	3	4	4

Table 9-14. Mine employment table 5.

Delivery Technique: Observer adjust Shell: M718/741 (RAAMS) Trajectory: Low angle BMA: Equal to or less than 800 mils										
RANGE (METERS)	DESIRED MINEFIELD WIDTH (METERS)									
	100	200	300	400	500	600	700	800	900	1,000
4,000	2	2	3	3	4	4	5	5	6	6
6,000	2	2	3	3	4	4	5	5	6	6
8,000	2	3	3	4	4	5	5	6	6	7
10,000	2	3	3	4	4	5	5	6	6	7
12,000	2	3	3	4	4	5	5	6	6	7
14,000	2	3	3	4	4	5	5	6	6	7
16,000	3	3	4	4	5	5	6	6	7	7
17,500	3	3	4	4	5	5	6	6	7	7

Table 9-15. Mine employment table 6.

Delivery Technique: Observer adjust Shell: M718/741 (RAAMS) Trajectory: Low angle BMA: Equal to or less than 800 mils											
RANGE (METERS)	DESIRED MINEFIELD WIDTH (METERS)										
		100	200	300	400	500	600	700	800	900	1,000
4,000	1	2	2	3	3	4	4	5	5	6	
17,500											

Table 9-16. Mine employment table 7.

Delivery Technique: Observer adjust Shell: M692/731 (ADAM) M718/741 (RAAMS) Trajectory: Low angle or high angle (ADAM) High angle (RAAMS) BMA: Equal to or less than 800 mils											
RANGE (METERS)	DESIRED MINEFIELD WIDTH (METERS)										
		100	200	300	400	500	600	700	800	900	1,000
4,000	1	1	1	2	2	2	2	3	3	3	
17,500											

Table 9-17. Mine employment table 8.

Delivery Technique: Observer adjust Shell: M692/731 (ADAM) M718/741 (RAAMS) Trajectory: Low angle or high angle (ADAM) High angle (RAAMS) BMA: Greater than 800 mils											
RANGE (METERS)	DESIRED MINEFIELD WIDTH (METERS)										
		100	200	300	400	500	600	700	800	900	1,000
4,000	1	1	2	2	2	2	3	3	3	3	
6,000	1	1	2	2	2	2	3	3	3	3	
8,000	1	2	2	2	2	3	3	3	3	4	
10,000	1	2	2	2	2	3	3	3	3	4	
12,000	1	2	2	2	2	3	3	3	3	4	
14,000	1	2	2	2	2	3	3	3	3	4	
16,000	2	2	2	2	3	3	3	3	4	4	
17,500	2	2	2	2	3	3	3	3	4	4	

9-16. LOCATION OF AIMPOINTS

a. Module Size 400 × 400 Meters, Even Number of Aimpoints. Place aimpoints 200 meters left and right of the center point along the centerline. Place the others at intervals of 400 meters (fig 9-19).

b. Module Size 400 × 400 Meters, Odd Number of Aimpoints. Place the first aimpoint at the center point of the minefield. Place the others at intervals of 400 meters left and right of the center point along the centerline (fig 9-20).

c. Module Size 200 × 200 Meters, Even Number of Aimpoints. Place the aimpoints 100 meters left and right of the center point along the centerline. Place the others at intervals of 200 meters.

d. Module Size 200 × 200 Meters, Odd Number of Aimpoints. Place the first aimpoint at the center point of the minefield. Place the others at intervals of 200 meters left and right of the center point along the centerline.

9-17. NUMBER OF PROJECTILES PER AIMPOINT

The number of projectiles required to achieve the desired density within each module (as defined by each aimpoint) is determined by entering table 9-18. Entry arguments are the projectile type, trajectory, and desired density.

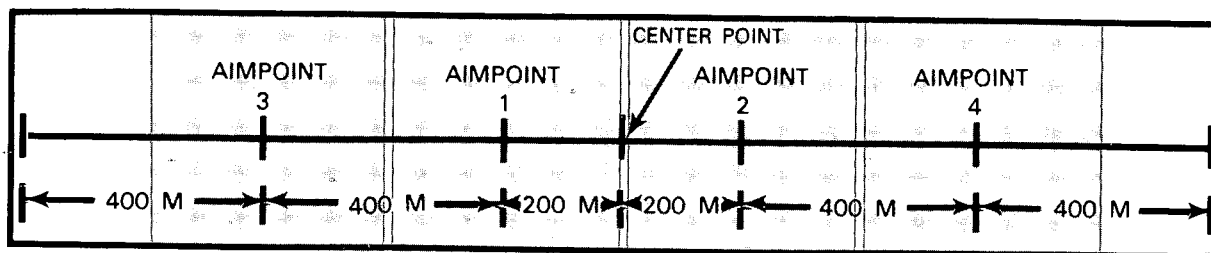


Figure 9-19. Module size 400 × 400 meters, even number of aimpoints.

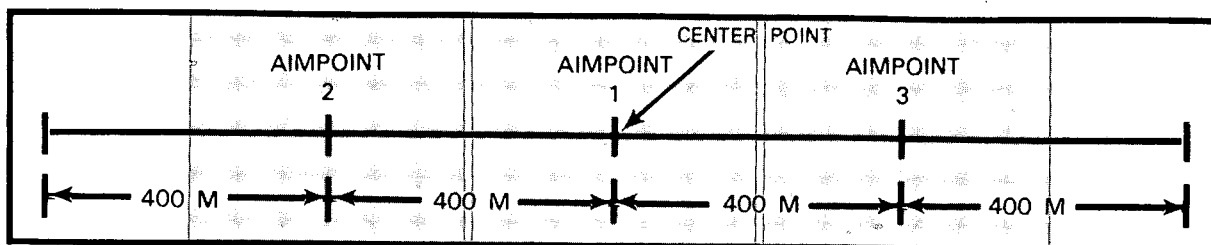


Figure 9-20. Module size 400 × 400 meters, odd number of aimpoints.

Table 9-18. M718/M741 RAAMS and M731 ADAM rounds per aimpoint.

HIGH ANGLE RAAMS				
Desired density	0.001	0.002	0.004	
Rounds per aimpoint	24	48	96	
LOW ANGLE RAAMS				
Desired density	0.001	0.002	0.004	
Rounds per aimpoint	6	12	24	
LOW ANGLE/HIGH ANGLE ADAM				
Desired density	0.0005	0.001	0.002	
Rounds per aimpoint	3	6	12	

EXAMPLE

On the basis of the minefield density information from section A, block 7, of the field artillery delivered minefield planning sheet, the FDO determines that six rounds should be fired at each aimpoint.

9-18. MANUAL DATA DETERMINATION

a. The FDO can now issue the fire order. See figures 9-21 and 9-22 for an example ADAM mission. The GFT setting in effect is GFT A: Chg 4, Lot IY, Rg 5340, El 378, Ti 21.9; GFT Df Corr: L2, Tot Df Corr: L9.

b. After the fire order has been issued, mission processing can begin. The computer issues initial fire commands.

c. The HCO determines and announces chart data to the minefield center, and the VCO determines site.

d. The computer, with the data determined in paragraph c above, records drift and determines a graze-burst quadrant. This quadrant is used as an entry quadrant to enter FT 155-ADD-L-1 to extract correction factors for low-level wind corrections.

Note. Low-level winds will cause ADAM mines to be blown away from the intended aimpoint. Consequently, a modification, in meters, to the location of the aimpoint must be made so that the mines land at the intended location.

RECORD OF FIRE																					
CALL FOR FIRE										TGT 373 GFT L2				△ PS							
Observer: AF/FFE/IS/S Tgt										BTRY 355 DFT L8				100/R							
Grid: AIM POINT: G3133800										VI + 18				/R							
Polar: Dir Dis U/D VA										⑥, DNL				20/R							
Shift: Dir U/R U/D										Si ÷ 10 10m Si				HOB Corr							
ADAM SHORT BEST RVCT, ⑥, ON CALL																					
FIRE ORDER # 1, 2 FFE, SPEC SHEAF, 2 AIM PTS, SH ADAMS, LOT BY, CHG 4, FZ TI										Df Corr				Si + 4							
INITIAL FIRE COMMANDS										✓ FM MF #1, 2 ⑥				Rg				Chf Df			
Sp Instr DNL										SH ADAMS Lot BY Chg 4 Fz TI Ti				Df				QE (434)			
MTO										T				PE				TF			
																		in Eff Ammo Exp			
Tgt	Location	Priority	Firing Unit	SUBSEQUENT FIRE COMMANDS														Exp	Type		
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si ()	El	QE							
				#1		(25.1)	2846	L10	(28.56)	5910		+4	439	(443)							
						(25.3)			(28.49)					(443)							
						25.1			28.49					549							
				#2		(25.1)	2846	L10	(28.56)	5910		+4	439	(443)							
						(23.6)			(28.73)					(415)							
						23.5			28.73					520							
FROM LINE 02 MET MSG, WIND DIR 5900 MILS																					
WIND SPEED 17 KNOTS																					
ENTRY QE: 435 → TBLA 7 FT 155 ADD-L-1: LOW LEVEL WIND CORR: +8.6 M/KNT																					
+8.6 X 17 = +146.2 + 150M																					
DETM SR-NODE QE TO INITIAL AIM PT. ENTER TBLA, ADD-L-1 WITH SR																					
QE TO EXTRACT LOW LEVEL WIND CORR, USE INFO FROM LINE 02 OF MET																					
MSG TO DETM DISPLACEMENT FOR LOW LEVEL WIND. SEE PARA 9-17 TO APPLY.																					
Btry A		DTG 5/22/84		Tgt AC 782		Replot Grid						Replot Alt									
DA FORM 4504		REPLACES DA FORM 4504, 1 MAR 76, WHICH IS OBSOLETE										FOR USE OF THIS FORM, SEE FM 6-40; THE PROPOSING AGENCY IS TRADOC									

Figure 9-21. Record of fire—ADAM mission.

FIELD ARTILLERY DELIVERED MINEFIELD PLANNING SHEET			
For use of this form see TC 6 20 5. The proponent agency is TRADOC.			
SECTION A MINEFIELD DATA			
1 TARGET NUMBER AC7821	2 PRIORITY	3 REQUESTER DIVISION G3	
4 MINEFIELD END POINTS (COORDINATES) FROM 6313 3800		ATTITUDE 0330 LENGTH 200M	
5 MINEFIELD DEPTH NA	6 MINEFIELD WIDTH NA		
7 ADAM (APERS) DENSITY 0.001	8 RAAMS (AT) DENSITY		
9 SELF DESTRUCT TIME SHORT ☒ LONG ☐	10 SCHEDULED MINEFIELD HRS MIN		ON CALL ☒
11 CAUTION NLT EMPLACEMENT TIME	12 APPROVAL AUTHORITY CG DIVISION	13 DATE TIME GROUP (DTG) DTG	
14 REMARKS PER REQUEST 1ST BDE			
SECTION B G3/S3/ENGR			
15 DTG RECEIVED DTG	16 DTG SAFETY ZONE DISSEMINATED DTG		
17 REMARKS			
SECTION C FSE FSO			
18 DTG TO UNIT DTG	19 DTG FROM UNIT DTG	20 DTG TO G3 S3 ENGR DTG	
21 REMARKS			
SECTION D FDC DATA			
22 TARGET NUMBER AC 7821	23 FIRING UNIT A	24 RANGE TO MINEFIELD CENTER 5830	
25 TRAJECTORY ADAM ☐ HIGH ☒ LOW RAAMS ☐ HIGH ☐ LOW		26 DELIVERY TECHNIQUE MIT - VE TRANSFER ☒ OBSERVER ADJUST ☐	
27 AIMPOINT (COORDINATE) (LEFT AND RIGHT OR SINGLE) ADAM FROM 6313 TO 3800 RAAMS FROM TO			
28 DTG MISSION COMPLETED 5/22/84 1400			
29 REMARKS			

Figure 9-22. Field artillery delivered minefield planning sheet—ADAM mission.

e. The computer enters FT 155-ADD-L-1, table A, column 1, with the entry quadrant. From column 5, he extracts the correction for a low-level wind of 1 knot.

f. The computer then extracts the wind direction and wind speed from line 02 of the current ballistic met message and multiplies the wind speed by the low-level wind correction factor.

g. The HCO places the target grid over the minefield center, orients the target grid on

the wind direction, plots an add correction equal to the value determined in paragraph f above, and determines chart data to the new displaced aimpoint.

h. The computer determines graze-burst data to the corrected aimpoint.

i. The computer applies special corrections to the graze-burst data determined in paragraph h above. The example uses gun 1 only.

GUN 1

$$\begin{aligned} \text{Ti (25.1)} + (-0.1) &= 25.0 \\ \text{Df (2856)} + (\text{R7}) &= 2849 \\ \text{QE (443)} + (+2) &= 445 \end{aligned}$$

GUN 2

$$\begin{aligned} \text{Ti (25.1)} + (-1.5) &= 23.6 \\ \text{Df (2856)} + (\text{L17}) &= 2873 \\ \text{QE (443)} + (-28) &= 415 \end{aligned}$$

j. The computer now applies the ballistic correction to the graze-burst data that have been modified by the special corrections. The ballistic corrections can be applied by using the GFT or FT 155-ADD-L-1.

(1) Ballistic corrections determined by use of the TFT for gun 1 are as follows:

(a) The computer enters FT 155-ADD-L-1, table A, column 1, with the graze-burst quadrant determined in paragraph *i* above (for gun 1) and extracts the ballistic correction from column 2.

(b) The computer algebraically adds the ballistic correction to the graze-burst quadrant.

(c) The computer enters FT 155-ADD-L-1, table B, column 1, with the graze-burst fuze setting determined in paragraph *i* above (for gun 1) and extracts the correction factor from column 2.

(d) The computer algebraically adds the correction to the graze-burst time.

(2) Ballistic corrections determined by use of the GFT for gun 2 are as follows:

(a) The computer places the MHL over the M577 graze-burst time (for gun 2) determined in paragraph *i* above on the M577 self-registering scale. Without moving the MHL, the computer reads up to the time scale labeled ICM 692/731, and reads time under the manufacturer's hairline.

(b) The computer now determines the dual-purpose quadrant by placing the MHL over the graze-burst quadrant on the graze-burst elevation scale for gun 2 determined in paragraph (a) above. Without moving the MHL, read up to the EL scale labeled ICM 692/731, and read the quadrant under the manufacturer's hairline.

k. The computer may now complete his fire commands.

l. The FDO now computes section D, block 27 of the field artillery delivered minefield planning sheet and forwards it to the fire support officer.

m. Procedures for emplacing a planned RAAMS minefield are identical to those for emplacing ADAM, except that low-level wind corrections are not applied.

9-19. M825 PROJECTILE

The M825 projectile is a field artillery delivered 155-mm base-ejection projectile designed to produce a smoke screen on the ground of 5 to 10 minutes duration. The smoke screen is produced when the payload is ejected from the projectile by a predetermined fuze action. After ejection, the WP-saturated felt wedges in the payload fall to the ground in an elliptical pattern. Each wedge then becomes a point source for smoke. The M825 is designed to be ballistically similar to the M483A1 family of projectiles. It consists of two major components—the projectile carrier and the payload. The projectile carrier delivers the payload, which consists of 116 WP-saturated felt wedges, to the target.

9-20. M825 COMPUTATION BY USE OF THE GFT AND TFT

Procedures for use of the M825 smoke projectile by use of the GFT and TFT are as follows: (See figure 9-23 for associated record of fire.)

Note. The GFT setting in effect is GFT A: Chg 4, Lot IY, Rg 5340, El 378, Ti 22.0; Tot Df Corr: L9, GFT Df Corr: L2.

a. The FDO analyzes the target and issues a partial fire order.

Note. The HE adjustment is conducted with DPICM in the self-registering mode.

b. The computer issues the initial fire commands.

c. The HCO determines and announces chart data, and the VCO determines site.

RELATIVE HUMIDITY 20%				RECORD OF FIRE													
Observer <u>H23</u>		CALL FOR FIRE APPEL/IS/ S <u>POLAR</u> Tgt		ALT TGT <u>343</u> GFT <u>L2</u>		△ FS											
Grid:				ALT BTRY <u>355</u> DRIFT <u>L6</u>		100/R											
Polar: Dir <u>5845</u> Dis <u>2020</u> U/D		VA		VI <u>-8</u> <u>L8</u>		/R											
Shift <u>SCREEN GAP IN TREELINE, 100M, CROSSWIND, 15 MIN, SWK</u>		U/D		Si $\div$ 10		10m Si											
FIRE ORDER <u>SH M825, LEFT & CENTER (8) TST AC 7822</u>				Di Corr <u>L8</u>		Si <u>-2</u>											
INITIAL FIRE COMMANDS		MF <u>45 (1)</u>		Rg <u>4820</u>		Cht Di <u>3102</u>											
Sp Instr		Sh <u>DP-SR</u> Lot <u>IY</u>		Chg <u>4</u> Ft <u>Ti</u> Ti <u>1080</u>		Di <u>3110</u>											
ATO <u>G, SH WPWICK, TGT AC 7822</u>		X <u>T (400)</u>		PEd		TF											
				LEFT & CENTER SH M825 LOT WY (8) in Eff		Ammo Exp <u>1</u> DP-SR											
Tgt	Location	Priority	Firing Unit	SUBSEQUENT FIRE COMMANDS												Exp	Type
MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Di	Di Corr (LQ)	Di Fired	Chart Rg	HOB Corr	Si +2)	EI	OE			
<u>6320</u>	<u>1200</u>	<u>+200</u>		<u>SH M825 LOT</u>			<u>(208) 3137</u>	<u>L8</u>	<u>(3145)</u>	<u>5070</u>		<u>-2</u>	<u>352</u>	<u>(350)</u>			
<u>SWK</u>				<u>WY</u>	<u>-0.9</u>	<u>19.6</u>		<u>+0</u>	<u>3145</u>		<u>+6</u>			<u>356</u>	<u>(1)</u>		
<u>FEE</u>				<u>LEFT A CTR</u>													
				<u>(8) BY RD ALT</u>													
				<u>SPEC CORR</u>													
				<u>LEFT ALT</u>											<u>(17)</u>		
				<u>CTR ALT</u>											<u>(33)</u>	<u>M825</u>	
				<u>FM</u>													
TREELINE SCREENED																	
GFTA: CHG 4, LOT IY, Rg 5340, EL 328, Ti 22.0, GFT DF CORR L2, TGT DF CORR L9																	
Dtry <u>A</u>		DTG <u>5/22/84</u>		Tgt <u>AC 7822</u>		Replot Grid		Replot Alt									

Figure 9-23. Record of fire—smoke M825.

Table 9-19. Relative humidity.

SCREEN REQUIREMENT	RELATIVE HUMIDITY (PERCENT)	TABLE
INFRARED	80	9-20
	50	9-21
	20	9-22
VISIBLE	80	9-23
	50	9-24
	20	9-25

d. The computer places the MHL over the announced range and records drift and elevation.

e. The computer determines and announces deflection to fire.

f. The computer determines and announces the self-registering quadrant to fire.

g. While initial fire commands are being completed, the FDO determines the amendments to his fire order.

(1) The FDO enters table 9-19 with the relative humidity furnished by the met station and infrared (ir) screen requirement determined from the fire order or the call for fire. He extracts the table he will use to develop his amendment.

Table 9-20. M825—near infrared, 80 percent relative humidity.

		WIDTH OF TARGET (METERS)								RATE OF FIRE	
ATMOSPHERIC CONDITIONS	WIND VELOCITY (KNOTS)	WIND DIRECTION								MINUTES BETWEEN ROUNDS (1 WEAPON)	MINUTES BETWEEN ROUNDS (1 PLATOON)
		CROSS				HEAD/TAIL					
IDEAL	5	300	1,100	1,600	1,700	90	200	400	650	5	6
FAVORABLE	5	400	900	1,300	1,400	90	200	400	600	3	5.5
	10	200	600	1,600	1,900	80	200	390	550	1	2.5
	15	100	400	1,600	2,000	70	180	370	550	1	1.5
MARGINAL	5	100	150	450	500	40	150	340	440	1	1.5
PLATOON TO FIRE		1/2	1	2	3	1/2	1	2	3		

Table 9-21. M825—near infrared, 50 percent relative humidity.

		WIDTH OF TARGET (METERS)								RATE OF FIRE	
ATMOSPHERIC CONDITIONS	WIND VELOCITY (KNOTS)	WIND DIRECTION								MINUTES BETWEEN ROUNDS (1 WEAPON)	MINUTES BETWEEN ROUNDS (1 PLATOON)
		CROSS				HEAD/TAIL					
IDEAL	5	500	1,000	1,300	1,400	90	200	400	600	3.5	5.5
FAVORABLE	5	200	600	1,100	1,200	80	200	400	600	2.5	4
	10	80	300	1,000	1,300	60	180	350	550	1	1.5
	15	60	200	700	1,300	50	160	330	500	.5	1
MARGINAL	5	60	150	350	450	30	100	300	350	1	1.5
PLATOON TO FIRE		1/2	1	2	3	1/2	1	2	3		

Table 9-22. M825—near infrared, 20 percent relative humidity.

		WIDTH OF TARGET (METERS)								RATE OF FIRE	
ATMOSPHERIC CONDITIONS	WIND VELOCITY (KNOTS)	WIND DIRECTION								MINUTES BETWEEN ROUNDS (1 WEAPON)	MINUTES BETWEEN ROUNDS (1 PLATOON)
		CROSS				HEAD/TAIL					
IDEAL	5	350	800	1,300	1,400	80	200	400	600	2.5	5
FAVORABLE	5	150	500	1,000	1,100	70	200	400	550	2	3.5
	10	50	250	700	1,100	50	160	330	500	1	1
	15	30	150	500	800	40	140	300	450	.5	.5
MARGINAL	5	40	100	300	400	30	100	250	300	1	1
PLATOON TO FIRE		1/2	1	2	3	1/2	1	2	3		

Table 9-23. M825—visible infrared, 80 percent relative humidity.

		WIDTH OF TARGET (METERS)								RATE OF FIRE	
ATMOSPHERIC CONDITIONS	WIND VELOCITY (KNOTS)	WIND DIRECTION								MINUTES BETWEEN ROUNDS (1 WEAPON)	MINUTES BETWEEN ROUNDS (1 PLATOON)
		CROSS				HEAD/TAIL					
IDEAL	5	900	1,400	1,200	1,900	100	200	440	660	6.5	8
FAVORABLE	5	700	1,100	1,500	1,600	100	200	440	650	5	6.5
	10	400	1,100	2,000	2,200	90	200	410	600	2	3.5
	15	200	900	2,200	2,400	80	200	400	550	1.5	2
MARGINAL	5	140	250	500	600	50	150	350	460	1.5	2
PLATOON TO FIRE		1/2	1	2	3	1/2	1	2	3		

Table 9-24. M825—visible infrared, 50 percent relative humidity.

			WIDTH OF TARGET (METERS)								RATE OF FIRE	
ATMOSPHERIC CONDITIONS	WIND VELOCITY (KNOTS)	WIND DIRECTION								MINUTES BETWEEN ROUNDS (1 WEAPON)	MINUTES BETWEEN ROUNDS (1 PLATOON)	
		CROSS				HEAD/TAIL						
IDEAL	5	800	1,200	1,700	1,800	100	200	430	640	5.5	7	
FAVORABLE	5	500	900	1,400	1,500	100	200	430	620	3.5	6	
	10	200	700	1,400	1,900	90	200	400	580	1.5	2.5	
	15	100	500	1,400	2,000	80	200	380	540	1	1.5	
MARGINAL	5									1.5	2	
PLATOON TO FIRE		1/2	1	2	3	1/2	1	2	3			

Table 9-25. M825—visible infrared, 20 percent relative humidity.

			WIDTH OF TARGET (METERS)								RATE OF FIRE	
ATMOSPHERIC CONDITIONS	WIND VELOCITY (KNOTS)		WIND DIRECTION								MINUTES BETWEEN ROUNDS (1 WEAPON)	MINUTES BETWEEN ROUNDS (1 PLATOON)
			CROSS				HEAD/TAIL					
IDEAL	5		650	1,100	1,500	1,600	90	200	420	630	5	7
FAVORABLE	5		300	800	1,300	1,400	90	200	400	600	3	5.5
	10		100	450	1,300	1,700	70	190	380	560	1	2
	15		50	300	1,300	1,700	60	190	360	530	1	1.5
MARGINAL	5		50	150	400	500	40	140	330	400	1.5	1.5
PLATOON TO FIRE			1/2	1	2	3	1/2	1	2	3		

EXAMPLE:

Entering table 9-19 with a relative humidity of 20 percent and no infrared requirement, the FDO extracts table 9-25.

(2) The FDO enters table 9-25 with the atmospheric conditions and wind speed (determined from the current ballistic message or personal observation) and target width and wind direction (as reported in the call for fire).

(3) To determine the number of rounds per gun to fire, the FDO divides the number of minutes smoke is required by the number of minutes between rounds.

(4) The FDO announces the amendment to his fire order.

h. The observer sends the subsequent correction and requests smoke.

(1) The HCO determines and announces chart data.

(2) The computer places the MHL over the announced chart range and determines graze-burst data.

(3) The computer enters FT 155-ADD-Q-1 with the appropriate charge and extracts corrections for the smoke round.

(a) Table A contains corrections to graze-burst quadrant and deflection. The computer enters column 1 with a self-registering quadrant. From column 2, he extracts the corrections and applies them to the graze-burst quadrant. From column 8, he extracts the corrections and applies them to the graze-burst deflection.

(b) Table B contains corrections to graze-burst time. The computer enters column 1 with the graze-burst time and extracts the corrections and applies them to the fuze setting.

(4) The computer announces firing data for shell smoke.

(5) The round is fired and the observer sends **FIRE FOR EFFECT**.

(6) The computer then computes special corrections for each platoon (chap 13).

SECTION III

ROCKET-ASSISTED MUNITIONS**9-21. CHARACTERISTICS**

a. Rocket-assisted projectiles (RAP) are available for the 105-mm, 155-mm, and 203-mm howitzers. They are designed to extend the range of the howitzers. The basic rocket-assisted projectiles are filled with high-explosive material. They produce blast and fragmentation in the target area. The 203-mm system also has a rocket-assisted nuclear projectile (M753) that is ballistically similar to its base HE rocket-assisted projectile. Computation procedures for the three basic HE RAP are identical. The ballistic computers and the hand-held calculator can be used to determine firing data for these projectiles. Consult the appropriate job aids for specific instructions. Manual procedures are discussed below. The

105-mm and 155-mm projectiles are fired only in the rocket-on mode. The 203-mm projectile may be fired in either the rocket-on or rocket-off mode.

b. The 105-mm rocket-assisted projectile is the M548. The 155-mm projectiles are the M549 and M549A1. For the M109A2/A3 weapons, these projectiles are fired with charges 7 (M4A2) and 8 (M119A1). The M198 howitzers may use charges 7 (M4A2), 8 (M119A1), 7R (M119A2), and 8S (M203 only for the M549A1 projectile). The 203-mm HE rocket-assisted projectile is the M650. It is the base projectile for the 203-mm M753 rocket-assisted atomic projectile. Rocket-assisted projectiles should always be fired by use of current GFT settings, because most RAP missions are expected to be fire-for-effect

missions. The multiplot GFT setting is recommended. When no RAP registration data are available, a multiplot GFT setting should be developed by use of muzzle velocity data, current powder temperature, and rocket motor temperature (assumed to be the same as the powder temperature).

9-22. MANUAL COMPUTATIONS

Manual procedures for computing HE RAP firing data are identical to those for conventional HE rounds. The rocket-assisted projectile GFTs and GSTs are similar to and read the same as those for conventional HE rounds with two exceptions. The 155-mm M549A1 GFT has no fuze setting scale, and the 203-mm M650 GFT has supplemental scales for the M753 nuclear projectile. The following is an example of a manual fire mission for the 155-mm RAP M549A1 (fig 9-24 and 9-25):

a. Upon receipt of the observer's call for fire, the FDO analyzes the target and issues the fire order. The RATELO composes and transmits the message to observer.

b. The computer determines and sends initial fire commands.

c. The HCO determines and announces chart data.

d. The VCO determines and announces site.

e. The computer determines, announces, and records firing data. If a GFT setting is available for the rocket-assisted projectile, firing data (drift, elevation, and time of flight) are determined by use of the appropriate gage lines. If no GFT setting is available, the computer will determine deflection, range, and fuze (203-mm only) corrections to GFT data by use of the TFT and met correction techniques (chap 10).

(1) Determine corrected chart data. Compute met data corrections on DA Form 4200 (Met Data Correction Sheet), and manually apply the corrections to the chart range and deflection.

(2) Use the GFT to determine drift, elevation, and time of flight corresponding to the corrected chart data. If no GFTs are available, use the TFT, and interpolate elevation and fuze setting (203-mm only) from table F.

(3) Complete, announce, and record the remainder of the fire commands.

Observer		T6B23		CALL FOR FIDE		Tgt		TGT 584 BTRY 516 VI + 68		△ FS	
Grid:		6421 3686		AR (FF) TS / S						100/D 6	
Polar: Dir				U/D		VA				/D	
Shift		Dir		U/R		+/-		U/D		20/D	
RADAR VEHICLE VT								4 Si ÷ 10		10m Si	
FIDE ORDER								Dt Corr		L13	
INITIAL FIDE COMMANDS								Dt Corr		3184	
Sp Instr ROCKET ON								Dt		3197	
MTO P ④ TGT AC 7816								Dt		522	
Tgt								in Eff		Acme Exp (24)	
SUBSEQUENT FIDE COMMANDS											
Dt Corr								Dt Fwd		Dt Rg	
HOD Corr								Si		EI	
Exp								Type			
CHT RG 16450											
TOT RG CORR +150											
CORR RG 516 600											
EL 16600 = 517											
FFE DATA IS COMPUTED FROM BTRY CENTER TO TGT CENTER SPECIAL CORRECTIONS FOR RAP ARE COMPUTED AS DISCUSSED IN CHAP 13.											
Dtry		DTG 5/23/84		Tgt AC 7816		Droplet Grid		Droplet Alt			

Figure 9-24. Example of a met data correction sheet—rocket-assisted projectile.

MET DATA CORRECTION SHEET									
For use of this form, see FM 6-40; proponent agency is TRADOC.									
BATTERY DATA					MET MESSAGE				
CHARGE	ADJ GE	CHART RG	LATITUDE	TYPE MESSAGE	OCTANT	AREA/UNIT			
7R		16450	30N	MET B-3	1	344983			
ALT OF DTRY (10 m)		520		DATE	TIME	ALT HDP	PRESSURE		
				12	1430	370	101.3		
ALT OF HDP		370		LINE NO.	WIND DIR	WIND SPEED	AIR TEMP	AIR DENSITY	
				06	2800	22	94.9	106.5	
DTRY ABOVE HDP (M)		150		A D CORRECTION			0.3 1.5		
ALT OF TARGET (Nooroot motor)		584		CORRECTED VALUES			94.6 105.0		
HEIGHT OF DURY ABOVE TARGET									
ALT OF DURY		584							
ALT OF DTRY (Nooroot motor)		516							
HEIGHT OF TARGET (Burst) ABOVE GUN (M)		+168 ≈ +100		COMP RG	CHART RG	ENTRY RG			
				+14	16450	16464	16500		
WIND COMPONENTS AND DEFLECTION									
WIND DIRECTION OF WIND IS LESS THAN DIR FIRE ADD		000		Pos DF 0					
DIRECTION OF WIND		2800		MET DF L13					
		9200		TOT DF L13					
DIRECTION OF (6116)		6100		ROTATION CORR 1.1					
CHART DIRECTION OF WIND		3100		DRIFT CORR 12.7					
CROSS WIND	WIND SPEED	22		COMP	0.10	KT	2	KNOTS	0.48
								UNIT CORR	
RANGE WIND	WIND SPEED	22		COMP	0.99	KT	22	KNOTS	12.8
								UNIT CORR	
MET RANGE CORRECTION									
	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS			
RANGE WIND	22	0	22	-16.5		363.0			
AIR TEMP	94.6	100%	5.4	+1.6	8.6				
AIR DENSITY	105.0	100%	5.0	+72.4	362.0				
PROJ WEIGHT	30	40	10	-40.0		40.0			
ROTATION		+11 X	91		9.6				
Pos VE	-3.5 P					380.2	403.0		
MVV	-5.2 P						380.2		
VE	-8.7 W						22.8		
						MET RANGE CORR -23			
COMPUTATION OF VE ROCKET MOTOR TEST P									
PROP TEMP	+90	VE P	-8.7	M/S	+30.8	TOTAL RANGE CORRECTION	-43P		
		CHANGE TO MV FOR PROP TEMP	+1.8	M/S	-30.2	MET RANGE CORRECTION	-23P		
		AV W	-6.9	M/S	MV UNIT CORRECTION +30.8	ΔV RANGE CORRECTION	+213P		
						TOTAL RANGE CORRECTION	+147W +150		
CORRECTION									

Figure 9-25. Example of a record of fire—rocket-assisted projectile.

9-23. REGISTRATION AND DETERMINATION OF THE GFT SETTING

In a combat environment, the unit may conduct registrations (chap 12), especially high-burst, with the rocket-assisted round for at least one weapon for a selected fire unit. For 105-mm and 155-mm howitzers, the GFT setting will provide increased accuracy in firing the rocket-assisted projectile. The M650 203-mm registrations will yield GFT

settings for the nuclear M753 K-transfer technique and for other conventional (RAP) 203-mm fire missions. An inferred GFT setting may also be computed if no registration is fired. A met solved concurrently with the GFT setting determination will establish position corrections for the met + VE technique. Position constants are determined by the solution of a concurrent met by use of the tabular firing tables (chap 10). If the rocket-on mode is used, range corrections for rocket motor temperature must be included.

Section IV NUCLEAR MUNITIONS

9-24. CHARACTERISTICS

The US Army howitzers are capable of delivering the M753 rocket-assisted nuclear projectile (203-mm), the M422A1 nuclear projectile (203-mm), and the M454 nuclear projectile (155-mm). Nuclear delivery techniques have the same accuracies and tolerances as those for conventional projectiles. Conventional rounds serve as the base rounds for both nuclear projectiles. Ballistic corrections are applied manually to HE firing data to determine the nuclear firing data.

a. The M753 projectile has an integral rocket motor and is ballistically similar to the M650A1 HE rocket-assisted projectile. The M753 projectile uses the same charge as the M650A1 projectile and is armed with the M735 electronic fuze. Because the M650A1 and the M753 are ballistically similar, the M650 projectile can be used to register and derive GFT settings and position constants for an M753 nuclear mission. The M650 projectile may also be used for observer adjustment with the M753 nuclear projectile fired in effect. All data computed for these projectiles are computed by use of FT 8-S-1 and related graphical equipment. The rocket motors in both projectiles may be fired either *rocket on* or *rocket off*.

b. The M422A1 projectile uses the M106 HE projectile as the basic round on which data are computed. It is armed by the M542 or

the T316E3 time fuze. Nuclear corrections to HE M106 data are determined and applied from FT 8-ADD-H-1.

c. The M424A1 high-explosive spotting (HES) round is used only in peacetime training to simulate a nuclear burst. It is not used in connection with either of the 203-mm nuclear projectiles. Firing table 8-ADD-I-1 (for training only) is used to determine corrections for the HES round from M106 firing data in the same manner the FT 8-H-1 is used to determine data for the M422A1 round. If the M106 GFT technique is used, a valid M106 GFT setting must be available, and the target must be accurately located within transfer limits. For this technique, the HE to nuclear/HES charge correlation in table 9-26 is used. The M753 and M650 projectiles use the M1, M2, and M188 or M188A1 propellants in the same manner.

Table 9-26. Charge correlation.

HE M106 PROPELLANTS	NUCLEAR M422A1 PROPELLANTS
CHARGE	CHARGE
1G, M1	1, M80
4G, M1	2, M80
6W, M2	3, M80
8, M188 or M188A1	8, M188 or M188A1

9-25. M753 DELIVERY TECHNIQUES

The three M753 delivery techniques that can be used are K-transfer, met + VE, and observer adjustment. Regardless of the technique used, all data are determined to the same accuracy as data in standard gunnery procedures. Firing data are recorded on DA Form 5336-R (203-mm Nuclear Computation Work Sheet for M753 Rocket-Assisted Projectile).

Note. Reproducible copies of new DA forms are in appendix J. Two-page forms should be reproduced head-to-head.

a. K-Transfer. With the K-transfer technique, registration corrections from an M650A1 RAP registration are used to determine data for the nuclear projectile. The M650 RAP data are modified to correct for ballistic differences, propellant temperatures (both the propelling charge and the rocket motor), and weight differences between the M650 RAP and the nuclear projectiles.

(1) **Requirements.** Use of the K-transfer technique requires a valid GFT setting from an M650 registration. Normally, a high-burst registration is conducted. The nuclear target must be accurately located and must be within registration transfer limits.

(2) **Accuracy.** The accuracy of the K-transfer technique depends on the validity of the GFT setting. As the time from the registration increases, the validity of the GFT setting decreases. Sudden changes in weather conditions will invalidate the GFT setting.

(3) **Speed.** The K-transfer technique is the fastest method of determining firing data.

b. Met + VE. When an M650 registration is conducted, position constants should be determined so that the subsequent met-to-target technique (chap 10) can be used.

(1) **Requirements.** Use of the met + VE technique requires that the target is accurately located and that position constants are available. A current met message is also required. The requirements for position constants are the same as those

for conventional firing. Position velocity errors include errors in the firing chart, met message, and survey. The position fuze correction for the M582 fuze can be transferred from one position to another. The position deflection correction can be transferred to a new location if common directional control exists between all positions.

(2) **Accuracy.** When the position VE for the M650 projectile is available, the met + VE technique is accurate. When registration data are not current or the target is outside or on the edge of the transfer limit, the met + VE technique is preferred. The accuracy depends on a current met message.

(3) **Speed.** The met + VE technique is slower than the K-transfer technique, because it requires the solution of a met to target.

c. Observer Adjustment. The observer adjustment technique requires the observer to adjust onto the nuclear target with the HE RAP and then fire for effect with the M753 nuclear projectile.

(1) **Requirements.** The observer adjustment technique requires an observer in position to observe the target. The observer must adjust for range and deviation. Since the M753 projectile uses a proximity fuze, there is no requirement to adjust height of burst; thus, a PD fuze may be used in adjustment.

(2) **Accuracy.** The accuracy depends on the observer's ability to adjust onto the target accurately.

(3) **Speed.** The speed of an observer adjustment mission depends on the speed of the observer in adjusting onto the target. Usually, observer adjustment is the slowest technique.

9-26. MANUAL DATA FOR K-TRANSFER TECHNIQUE (M753)

a. The RAP nuclear (M753) K-transfer technique requires the use of a GFT setting and a GFT deflection correction. The example (fig 9-26) uses the following GFT setting: GFT B: Chg 7R, Lot MA, Rg 20,000, El 630, Ti 60.7; GFT Df Corr: L4, Tot Df Corr: L25.

RECORD OF FIRE			
Observer <u>SEE ATTACHED MSG</u>	CALL FOR FIRE AF/PPE/IS/S	Tgt <u>FC 7822</u>	TGT ALT <u>404</u> BTRY ALT <u>319</u>
Grid: _____			
Polar: Dir _____	Dis _____	U/D _____	VA _____
Shift _____	Dir _____	L/R _____	+/- _____ U/D _____
FIRE ORDER			Df Corr
INITIAL FIRE COMMANDS	☒ FM	M/F # <u>10</u>	Dg <u>18720</u> Cht Df <u>2980</u>
Sp Instr <u>AMC</u>	Sh <u>NUC</u>	Lot <u>QA</u>	Chg <u>Fz Ti</u> Ti <u>Di</u>

Figure 9-26. Record of fire—K-transfer technique.

b. The K-transfer technique requires corrections for HE RAP and nuclear projectile weights, propellant temperatures, and rocket motor temperatures and requires the determination of ballistic corrections. The ballistic corrections for the nuclear projectile are applied to the final fuze setting, deflection, and quadrant elevation computed for the HE RAP.

c. Usually, the target information is sent to the unit in a message from higher headquarters. It should contain the target grid location, altitude, and desired height of burst.

d. The chart range and deflection to the target must be recorded on the record of fire. The FDO must decide which of the three techniques he will use. The data in the example (fig 9-26) are within transfer limits of the high-burst location, and the GFT setting is valid. Therefore, he will use the K-transfer method.

e. To compute the mission, the FDC must have the propellant temperatures, projectile weights, and rocket motor temperatures of the HE RAP used in the registration. The FDC also must have the weight, propellant temperature, and rocket motor temperature of the nuclear projectile at the time the mission is being computed. For HE RAP, the temperature of the rocket motor is assumed to be the same as the temperature of the propellant. Although the M753 nuclear projectile uses the same propellant as the M650, the propellant used to fire the M753 and that used to fire the M650 may be stored separately. Therefore, provisions are made in these calculations for variations between

propellant and rocket motor temperatures for the nuclear projectile and those for the HE RAP. The differences in propellant temperatures, projectile weights, and rocket motor temperatures must be determined; and a corresponding range correction, in meters, must be applied to the chart range. The result is a corrected range at which the firing data will be computed.

f. DA Form 5336-R is used for 203-mm nuclear computations (M753 projectile).

(1) Use blocks 1 through 8 (fig 9-27) when determining entry range. An entry range is necessary to determine unit corrections for propellant temperatures, projectile weights, and rocket motor temperatures. Use the same procedure to determine entry range as that used for solving a met.

STEP	PROCEDURE	VALUE
1	ALTITUDE OF TARGET (1 METER)	404
2	HEIGHT OF BURST ABOVE TARGET (1 METER)	+150
3	ALTITUDE OF BURST (1 + 2) (1 METER)	554
4	ALTITUDE OF BATTERY (1 METER)	319
5	HEIGHT OF BURST ABOVE GUN (3 - 4) (1 METER)	235
6	CHART RANGE TO TARGET (10 METERS)	18720
7	COMPLEMENTARY RANGE (TABLE B) (1 METER)	+28
8	ENTRY RANGE (6 + 7) (1 METER) (100 METERS)	18748

Figure 9-27. Determination of entry range—K-transfer.

(2) Use blocks 9 through 13 (fig 9-28) when determining corrections for differences in propellant temperatures, projectile weights, and rocket motor temperatures.

(a) *Propellant temperature.* Determine the change to muzzle velocity to compensate for the change in propellant temperature (table 9-27). Determine the difference (increase or decrease) between the muzzle velocities (in fig 9-28, -0.4 meter per second from -0.6 meter per second = a decrease of 0.2 meter per second). The unit correction factor (table F at entry range 18700, column 10, for decrease) is +36.6. Determine the correction, in meters, for the change in propellant temperature by multiplying $0.2 \times +36.6 = +7.32 \approx +7$.

8	ENTRY RANGE ([6] + [7]) (18748 (1 METER)) (100 METERS)	18700
9	Δ MUZZLE VELOCITY (TABLE E) (NUCLEAR PROJECTILE POWDER TEMPERATURE [+65 °F]) (0.1 METER PER SECOND)	-0.6
10	Δ MUZZLE VELOCITY (TABLE E) (HIGH-EXPLOSIVE/ROCKET- ASSISTED PROJECTILE POWDER TEMPERATURE [+67 °F]) (0.1 METER PER SECOND)	-0.4
11	DIFFERENCE ([9] - [10]) (0.1) DECREASE INCREASE	-0.2
12	UNIT CORRECTION (TABLE F, COLUMN 10/11) (0.1)	+36.6
13	CORRECTION FOR PROPELLANT CHARGE TEMPERATURE ([11] × [12]) (1 METER)	+7

Figure 9-28. Corrections for difference in propellant temperature—K-transfer.

(b) *Projectile weight.* The weight of the HE RAP is measured in squares, with 4 squares being standard. The weight of the nuclear projectile is measured in pounds, with 200.0 being standard. Firing table 8-S-1

gives corrections in range in terms of square weight. To calculate a correction for a change in weight (fig 9-29), convert the weight of the HE RAP to pounds. Then find the difference between that weight and the weight of the nuclear projectile in pounds. Convert that difference to squares. Then determine the range correction. The standard weights of the HE RAP are on page VI of the introduction of FT 8-S-1. From the table, it is possible to infer that a difference in weight of 1 square equals a difference of 2.5 pounds.

14	NUCLEAR PROJECTILE WEIGHT (0.1 POUND)	201.0
15	HIGH-EXPLOSIVE/ROCKET- ASSISTED PROJECTILE WEIGHT (_____) (PAGE VI, TFT) (0.1 POUND)	197.5
16	DIFFERENCE ([14] - [15]) (0.1 POUND) DECREASE INCREASE	3.5
17	DIFFERENCE IN SQUARE WEIGHT ([16] ÷ 2.5) (0.1) DECREASE INCREASE	1.4 = 1.4
18	UNIT CORRECTION (TABLE F, COLUMN 18/19) (1 METER)	+48.0
19	CORRECTION FOR PROJECTILE WEIGHT ([17] × [18]) (1 METER)	+48
20	NUCLEAR PROJECTILE/ROCKET MOTOR TEMPERATURE RANGE CORRECTION (TABLE E 1) (1 METER)	

DA FORM XXXA-R SEP 84 (CONFIDENTIAL)

Figure 9-29. Corrections for projectile weight—K-transfer.

(c) *Rocket motor temperature.* Determine the difference (increase or decrease) between range corrections by using FT 8-S-1, table E.1, and by calculating the change between HE RAP and rocket-assisted nuclear projectiles (fig 9-30 and table 9-27). The range correction for HE RAP rocket motor temperature (+67° F) is 0 when using the nearest listed temperature and range. The nuclear range correction is 16 meters at a

Table 9-27. Example data.

PROJECTILE WEIGHT	PROPELLANT TEMPERATURE	ROCKET MOTOR TEMPERATURE
HE/RAP: 3 squares	+67° F	+67° F
Nuclear: 201.0 pounds	+65° F	+65° F

temperature of +65° F. The difference in range from HE/RAP to nuclear is 0 to +16, or +16 meters. For *rocket off* missions, this step is deleted.

20	NUCLEAR PROJECTILE ROCKET MOTOR TEMPERATURE RANGE CORRECTION (TABLE E 1)	(1 METER)	+16
FORM 9-30			
STEP	PROCEDURE		VALUE
21	HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE ROCKET MOTOR TEMPERATURE RANGE CORRECTION (TABLE E 1)	(1 METER)	0
22	DIFFERENCE (20 - 21)	(1 METER)	+16

Figure 9-30. Corrections for rocket motor temperature—K-transfer.

(d) *Corrected range.* Determine the corrected range as shown in figure 9-31 by adding the corrections, in meters, for the projectile weight, propellant temperature, and rocket motor temperature to the initial chart range to the same accuracy as that for chart range (10 meters). The corrected range must be determined before any values on the GFT can be determined.

Propellant temperature correction	+7 meters
Projectile weight correction	+48 meters
Temperature correction— rocket on	+16 meters
Initial chart range	+ 18,720 meters
Corrected range	18,791 meters ≈ 18,790 meters

23	CORRECTED RANGE (6 + 13 + 19 + 22)	(10 METERS)	18790
ELEVATION ~ 23 (HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE)			

Figure 9-31. Corrected range—K-transfer.

(3) Use blocks 24 through 26 (fig 9-32) when determining HE RAP quadrant elevation. Determine the HE RAP quadrant

elevation with the current GFT setting. With the corrected range set under the MHL, read the elevation under the elevation gage line (block 24). Determine site and angle of site with the GST, and enter the data in block 25. Add site to elevation to determine HE RAP quadrant elevation (block 26).

24	ELEVATION ~ 23 (HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE GFT SETTING)	(1 MIL)	549
25	SITE (GFT VERTICAL INTERVAL ~ 5 AT RANGE 6)	(1 MIL)	+15
26	QUADRANT ELEVATION FOR HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE (24 + 25)	(1 MIL)	564
ANGLE OF SITE			

Figure 9-32. Determination of HE/RAP quadrant elevation—K-transfer.

(4) Use blocks 27 through 31 (fig 9-33) when determining fuze settings. Determine angle of site with the GST, and enter the data in block 27. The fuze setting to fire is the M735 electronic time setting corresponding to elevation plus comp site plus ballistic correction from part 2, table B, of the tabular firing table. Determine elevation plus comp site (block 28) and place that number under the elevation gage line. Read the fuze setting under the time gage line. The ballistic correction to be applied to the M735 electronic time fuze is in part 2, table B, of the tabular firing table.

27	ANGLE OF SITE (GST C AND D SCALES)	(1 MIL)	+13
28	ELEVATION + COMPLEMENTARY ANGLE OF SITE (24 + 27)	(1 MIL)	551
29	FUZE SETTING ~ 28 (HIGH-EXPLOSIVE ROCKET-ASSISTED PROJECTILE GFT SETTING)	(0.1)	54.2
30	BALLISTIC FUZE CORRECTION FOR NUCLEAR PROJECTILE (PART 2, TABLE B)	(0.1)	-2.8
31	FUZE SETTING TO FIRE (29 + 30)	(0.1)	51.4

Figure 9-33. Determination of fuze setting—K-transfer.

(5) Use blocks 32 through 35 (fig 9-34) when determining deflection to fire. Add a ballistic correction from part 2, table A. Add the deflection correction and ballistic correction to the chart deflection as shown.

31		(1 MIL)	
32	CHART DEFLECTION TO TARGET	(1 MIL)	2980
33	DEFLECTION CORRECTION (GFT)		
33	DEFLECTION CORRECTION <u>L14</u>		
33	DRIFT ~ ELEVATION <u>24</u> <u>L18</u>	(1 MIL)	L22
34	BALLISTIC DEFLECTION CORRECTION		
34	(PART 2 TABLE A) <u>0</u>	(1 MIL)	0
35	DEFLECTION TO FIRE (<u>32</u> + <u>33</u> + <u>34</u>)	(1 MIL)	3002
35	QUADRANT ELEVATION FOR		

Figure 9-34. Determination of deflection—K-transfer.

(6) Use blocks 36 through 38 (fig 9-35) when determining nuclear quadrant elevation. Determine the QE to fire by applying a ballistic correction from part 2, table A, to the HE QE already determined. The fire commands are now complete.

35	DEFLECTION TO FIRE (<u>32</u> + <u>33</u> + <u>34</u>)	(1 MIL)	
36	QUADRANT ELEVATION FOR HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE <u>28</u>	(1 MIL)	564
37	BALLISTIC CORRECTION FOR NUCLEAR PROJECTILE (PART 2, TABLE A)	(1 MIL)	+ 4
38	QUADRANT ELEVATION TO FIRE (<u>36</u> + <u>37</u>)	(1 MIL)	568

Figure 9-35. Determination of nuclear quadrant elevation—K-transfer.

9-27. MET + VE TECHNIQUE

a. The computation of met + VE for nuclear missions requires a fuze setting corresponding to elevation plus comp site and a rocket motor correction. As in the K-transfer technique, correct the ballistic

differences between the M650 and M753 projectiles by using values from part 2 of the tabular firing table.

b. A message is received with target information for the nuclear mission. The example includes a height of burst of 95 meters. Use the met + VE technique.

c. To determine the data to fire, solve a met to target by using position constants and the most current nuclear data (propellant temperature, rocket motor temperature, and projectile weight) (fig 9-36). If a quadrant elevation can be implied, use table A of the TFT to determine the met line number. If no QE can be implied, use table B.

MET DATA CORRECTION SHEET									
For use of this form, see FM 6-40; proponent agency is TRADOC.									
BATTERY DATA					MET MESSAGE				
CHARGE	ADJ QE	CHART RG	LATITUDE	TYPE MESSAGE	OCTANT	AREA/UNIT			
7R	—	17.750	30°N						
ALT OF BTRY (10 m)		320		DATE	TIME	ALT MDP	PRESSURE		
ALT OF MDP		330		LINE NO.	WIND DIR	WIND SPEED	AIR TEMP	AIR DENSITY	
BTRY ABOVE MDP (AM)		-10		A & B CORRECTION					
ALT OF TARGET (nearest meter)		412		CORRECTED VALUES					
HEIGHT OF BURST ABOVE TARGET		+95							
ALT OF BURST		507							
ALT OF BTRY (nearest meter)		319							
HEIGHT OF TARGET (above) ABOVE GUN (RD)		+188	+190	COMP RG	CHART RG	ENTRY RG			
WIND CORRECTIONS AND DEFLECTION									
DIRECTION OF FIRE									
CHART DIRECTION OF WIND									
CROSS WIND	WIND SPEED	* COMP R	* L	* R	* KNOTS	* UNIT CORR	CROSS WIND CORR	* 1.3	
RANGE WIND	WIND SPEED	* COMP R	* L	* R	* KNOTS	* UNIT CORR	RANGE WIND CORR	* 1.84	L18
MET RANGE CORR									
COMPUTATION OF VE									
PROP TEMP	VE	M/S		TOTAL RANGE CORRECTION					
CHARGE TO MV FOR PROP TEMP	AV	M/S		MET RANGE CORRECTION	+15				
AV	M/S			AV RANGE CORRECTION	+90				
OLD VE				NEW VE	AVG VE				
MET FUZE CORRECTION									
AV	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS					
RANGE WIND									
AIR TEMP									
AIR DENSITY									
PROJ WEIGHT									
TOTAL FUZE CORRECTION									
MET FUZE CORRECTION						-0.2			
FUZE CORRECTION						-0.2			
TOTAL FUZE CORRECTION						-0.4	-0.4		
MET FUZE CORR									
OLD FUZE CORR									
NEW FUZE CORR									
BATTERY									
DATE/TIME									

Figure 9-36. Manual data for met + VE technique.

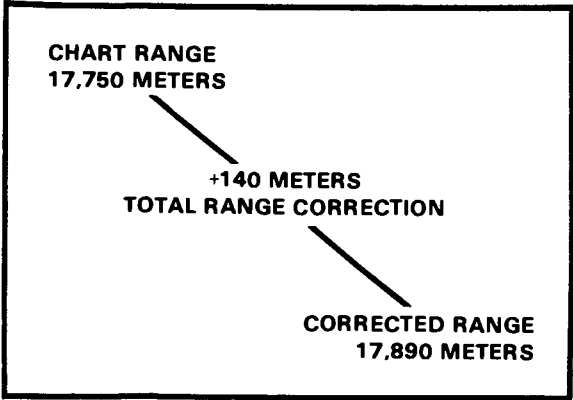


Figure 9-37. Corrected range—met + VE.

d. After the met is solved, perform the remainder of the computations on DA Form 4200. To determine a corrected range, apply the total range correction (from the met) to the chart range (fig 9-37).

e. Determine the HE RAP quadrant elevation by placing the MHL over the corrected range (block 4). Then compute and add site (fig 9-38). Determine angle of site and enter the data on the form.

f. Determine the fuze setting for HE RAP by placing the MHL over elevation plus comp site. Add the total fuze correction from the met (fig 9-39).

1	HEIGHT OF BURST ABOVE GUN (MET FORM)	(1 METER)	
2	CHART RANGE TO TARGET	(10 METERS)	17,750
3	TOTAL RANGE CORRECTION (MET FORM)	(10 METERS)	+140
4	CORRECTED RANGE (2 + 3)	(10 METERS)	17,890
5	ELEVATION ~ 4 (USE MANUFACTURER'S HAIRLINE)	(1 MIL)	494
6	SITE (GFT, VERTICAL INTERVAL 1 AT RANGE 2)	(1 MIL)	+12
7	QUADRANT ELEVATION FOR HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE (5 + 6)	(1 MIL)	506
8	ANGLE OF SITE (GFT, C- AND D-SCALES)	(1 MIL)	

Figure 9-38. Determination of HE/RAP quadrant elevation—met + VE.

7	QUADRANT ELEVATION FOR HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE (5 + 6)	(1 MIL)	506
8	ANGLE OF SITE (GFT, C- AND D-SCALES)	(1 MIL)	+11
9	ELEVATION + COMPLEMENTARY ANGLE OF SITE (7 - 8)	(1 MIL)	495
10	FUZE SETTING ~ 9 (USE MANUFACTURER'S HAIRLINE)	(0.1 MIL)	49.5
11	TOTAL FUZE CORRECTION (MET FORM)	(0.1 MIL)	-0.4
12	FUZE SETTING FOR HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE (10 + 11)	(0.1 MIL)	49.1
13	BALLISTICS (PART 2, TABLE 8)		

Figure 9-39. Determination of HE/RAP fuze setting—met + VE.

g. To determine the data to fire, apply the ballistic corrections from part 2, tables A and B, to the HE RAP deflection, fuze setting, and quadrant elevation. Enter part 2 data at items 13, 17, and 19 (fig 9-40 and 9-41).

Note. The fuze setting to fire is the fuze setting for HE RAP plus the ballistic correction (fig 9-40).

h. Determine the deflection to fire by applying the total deflection correction from the met and the ballistic correction to the chart deflection (fig 9-41).

i. The quadrant to fire the HE RAP round has already been determined. Determine the nuclear QE by applying the ballistic correction from part 2, table A. The fire commands are complete for this mission (fig 9-41).

j. There may be rare occasions when a position VE is not available and a

registration or observer adjustment is impossible. When this happens, extract a position VE from the approximate loss in muzzle velocity table on page IX of the firing table. Enter the table with the ordnance-provided pullover gage reading (preferred method) or equivalent full charge erosion rounds.

9-28. OBSERVER ADJUSTMENT TECHNIQUE

a. If the requirements for the met + VE or K-transfer technique cannot be met, an observer may be used to adjust the HE RAP onto the nuclear target. Shell nuclear is fired in effect. If the observer adjustment technique must be used, an observer will be in position to observe the target. To adjust, use M650 projectiles fuzed with M577 fuzes. The fuze settings are not adjusted, because they can be determined from the MPI registration scale on the GFT for M735 fuzes.

12	FUZE SETTING FOR HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE ($\boxed{10} + \boxed{11}$)	(0.1 MIL)	
13	BALLISTIC FUZE CORRECTION FOR NUCLEAR PROJECTILE (PART 2, TABLE B)	(0.1 MIL)	-2.7
14	FUZE SETTING TO FIRE ($\boxed{12} + \boxed{13}$)	(0.1 MIL)	46.4
	CHART DEFLECTION TO TARGET	(1 MIL)	

Figure 9-40. Determination of nuclear fuze setting—met + VE.

15	CHART DEFLECTION TO TARGET	(1 MIL)	3354
16	TOTAL DEFLECTION CORRECTION (MET FORM)	(1 MIL)	L30
17	BALLISTIC DEFLECTION CORRECTION (PART 2, TABLE A) (_____ (0.1 MIL))	(1 MIL)	0
18	DEFLECTION TO FIRE ($\boxed{15} + \boxed{16} + \boxed{17}$)	(1 MIL)	3384
19	QUADRANT ELEVATION FOR HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE ($\boxed{7}$)	(1 MIL)	506
20	BALLISTIC CORRECTION FOR NUCLEAR PROJECTILE (PART 2, TABLE A)	(1 MIL)	+4
21	QUADRANT ELEVATION TO FIRE ($\boxed{18} + \boxed{20}$)	(1 MIL)	510

Figure 9-41. Completion of fire commands—met + VE.

b. To determine nuclear firing data, recompute the site to include the height of burst, and determine the fuze setting corresponding to elevation plus comp site. Recompute the new HE RAP quadrant elevation with the new site. Entry arguments into the ballistic correction tables of the TFT are the new HE RAP quadrant elevation and the M735 fuze setting. If there is a difference in projectile weight and/or temperature, an entry range must be computed by using vertical interval, chart range, and part 1, table B. The final chart range must be modified by the range correction for projectile weight, propellant temperature, and rocket motor temperature before the HE RAP quadrant elevation can be determined. This procedure is the same as that for the K-transfer technique.

c. Consult the BCS job aids to determine firing data for the M753.

d. Consult the FADAC job aids to determine firing data for the M650/M753 projectile combination.

9-29. M422A1 DELIVERY TECHNIQUE

a. The only authorized computation technique for the M422A1 nuclear projectile is to use FT 8-ADD-H-1 to determine ballistic corrections for the round. FT 8-ADD-I-1 is used in computing data for the M424A1 HES training round. Both projectiles use the same technique. Only the addendum changes. There is no GFT equipment for these projectiles. Any previously used equipment is now obsolete. All HE data in this section use FT 8-Q-1.

Correction factors from FT 8-ADD-H-1 are applied to the HE data to determine M422A1 firing data.

b. When an HE GFT setting and GFT deflection correction are used, the fire-for-effect data are modified. The fuze setting, deflection, and quadrant elevation are modified by corrections from the firing table and the appropriate addendum. During training missions, the M564 time fuze may be used instead of the M582 fuze. The procedures are the same, except that the expected delivery accuracy may be less because of the larger M564 fuze probable errors.

c. Range corrections are computed for the nuclear propellant temperature and weight differences. These corrections account for changes in muzzle velocity.

(1) Projectile weight range corrections are listed in FT 8-Q-1, table F, columns 18 and 19. Enter the appropriate charge at the nearest listed range to the target. This table lists range corrections, in meters, for a difference of 1 square weight. Table 9-28 lists the square weights of the HE, nuclear, and HES projectiles based on weight in pounds.

(2) Propellant temperature corrections are in table C of the addendum. Enter the table at the nearest listed range and the nearest listed temperature. Do not interpolate when using this table. If the difference between HE and nuclear (HES) propellant temperatures is greater than +10° F, recompute the GFT setting by using the nuclear (HES) temperature in the subsequent met (chap 10). If the difference is less than +10° F, use the current HE GFT setting.

(3) Algebraically add the range corrections for propellant temperature and

Table 9-28. Pound weight to square weight.

FUZED WEIGHT IN POUNDS			
SQUARE WEIGHT	HIGH EXPLOSIVE (M106)	NUCLEAR M422A1	HIGH-EXPLOSIVE SPOTTING M424A1
3	197.5	238.3 to 240.7	238.3 to 240.7
4 ¹	200.0	240.8 to 243.2	240.8 to 243.2
5	202.5	243.3 to 245.7	243.3 to 245.7

¹ Standard.

projectile weight to the chart range to determine the corrected range.

d. Site is determined between the piece to fire and the target (including height of burst). Since the vertical interval will normally be greater than 100 meters, comp site must be determined and applied. Elevation plus comp site is used to determine the fuze setting for the M582 fuze.

e. The HE QE is determined by algebraically adding elevation plus site.

f. The HE deflection is determined by algebraically adding chart deflection plus drift plus the GFT deflection correction.

g. The HE firing data are corrected to compensate for differences between the two projectiles.

(1) Enter table A of the appropriate charge in the addendum. Use the HE quadrant elevation, expressed to the nearest listed value, and obtain the quadrant elevation and deflection ballistic corrections for shell nuclear (HES).

(2) Enter table B of the addendum with the HE fuze setting. Obtain the correction to fuze setting for the nuclear (HES) projectile.

(3) Algebraically add the corrections to the appropriate HE data to determine the nuclear (HES) firing data.

h. Figures 9-42 and 9-43 show a completed record of fire and a completed DA Form 5337-R (203-mm Nuclear Computation Work Sheet for M422A1). The following data are used for computation.

[illegible]

Figure 9-42. Completed record of fire.

203-MM NUCLEAR COMPUTATION WORK SHEET FOR M422A1							
For use of this form, see FM 6-40; proponent agency is TRADOC							
STEP	ENTER						
1	M106 GFT SETTING B	CHARGE 6	LOT XP	RANGE 10850	ELEVATION 411	TIME 333	GFT DEFLECTION CORRECTION L9
KNOWN DATA							
2	BATTERY ALTITUDE —		TARGET ALTITUDE —		CHART RANGE 11,450		DATE 5/22/84
	PROPELLANT TEMPERATURE +38°F(NUC) +47°F(M3)		HIGH-EXPLOSIVE PROJECTILE WEIGHT 4 □		NUCLEAR PROJECTILE WEIGHT 239.8 ≈ 3 □		TIME 2200
ENTER THE INTRODUCTION TO FT 8-ADD-H-1 FOR CORRESPONDING CHARGE FROM 1 ABOVE						3,1480	
STEP	PROCEDURE					VALUE	
3	RANGE CORRECTION FOR PROPELLANT TEMPERATURE (FT 8-ADD H 1, TABLE C).					+22	
4	RANGE CORRECTION FOR PROJECTILE WEIGHT DIFFERENCE (FT 8 Q 1, TABLE F).					-19	
5	[3] + [4] = CORRECTED RANGE.					11453 ≈ 11450	
6	ADD TARGET ALTITUDE AND HEIGHT OF BURST.					(FROM CLASSIFIED MSG)	
7	SUBTRACT BATTERY ALTITUDE FROM STEP [6] = VERTICAL INTERVAL.					+247	
8	DETERMINE SITE CORRESPONDING TO STEP [7] (GST).					+26	
9	IF VERTICAL INTERVAL IS GREATER THAN OR EQUAL TO 100, USE C AND D SCALES TO DETERMINE ANGLE OF SITE. IF VERTICAL INTERVAL IS LESS THAN 100, GO TO STEP [11].					+22	
10	SUBTRACT STEP [9] FROM STEP [8] = COMPLEMENTARY ANGLE OF SITE.					—	
11	DETERMINE ELEVATION ~ CORRECTED RANGE (STEP [5]).					+4	
12	DETERMINE FUZE SETTING ~ ELEVATION + COMPLEMENTARY ANGLE OF SITE (STEP [10]).					447	
13	ADD STEPS [8] AND [11] = HIGH-EXPLOSIVE QUADRANT ELEVATION.					35.7	
14	ADD CHART DEFLECTION + DRIFT + GFT DEFLECTION CORRECTION = THE DEFLECTION.					3289 L12 L9 3310	
15	CORRECTIONS TO HIGH-EXPLOSIVE QUADRANT ELEVATION FOR SHELL NUCLEAR (FT 8-ADD H 1, TABLE A).					-45.2	
16	CORRECTIONS TO HIGH-EXPLOSIVE DEFLECTION FOR SHELL NUCLEAR (FT 8-ADD H 1, TABLE A).					R4.0	
17	CORRECTIONS TO HIGH-EXPLOSIVE FUZE FOR M591 FUZE (FT 8-ADD H 1, TABLE B).					-0.9	
18	ADD STEPS [12] AND [17] = NUCLEAR TIME M591.					34.8	
19	ADD STEPS [14] AND [16] = NUCLEAR DEFLECTION.					3306	
20	ADD STEPS [13] AND [18] = NUCLEAR QUADRANT ELEVATION.					424	

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Figure 9-43. Completed DA Form 5337-R.

(1) Battery B has just conducted a registration. The unit receives a nuclear fire mission. The mission message gives the target location, altitude, and height of burst. The fire order and initial fire commands are announced. The current GFT setting is GFT B: Chg 6, Lot XY, Rg 10950, El 411, Ti 33.3; GFT Df Corr: L9. Charge 6WB, M2 corresponds to charge 3, M80 propellant. Other known information is as follows:

M80 propellant charge temperature	+38° F	
M2 temperature	+47° F	
M422A1 projectile weight	239.8	pounds
M106 weight	4	squares
Chart range to target	11,450	meters
Chart deflection	3,289	mils
Vertical interval	+247	meters

(2) Determine and apply range corrections for propellant temperature and projectile weight to the chart range. Enter FT 8-Q-1, table F, charge 6, at the nearest listed range (11,400). From columns 18 and 19, extract the range correction for a change in 1 square weight (decrease -19 meters, increase +20 meters). Determine the difference in square weight from HE to nuclear using table 9-28.

HE weight - nuclear weight (239.8) = change in square weight
4 squares - 3 squares = decrease of 1 square

(a) Multiply the -19 meter decrease square weight factor by 1 (square difference) to yield a -19 meter range correction for projectile weight change.

(b) Enter table C of the addendum with the temperature expressed to the nearest listed value (+48 ≈ +50) and the range expressed to 11000. The range correction is determined to be +22 meters.

(c) The corrected range is:

Chart range	11450
Propellant temperature range correction	+22
Projectile weight correction	-19
Corrected range	<u>11453</u> ≈ 11450

(3) Now determine site by using chart range (11450). The vertical interval is +247 meters. Site is +26 mils.

(4) Since the vertical interval is greater than 100 meters, determine and add comp site to elevation to determine the fuze setting (site [+26] - angle of site [+22] = comp site [+4]). Fuze setting is 35.7 corresponding to elevation plus comp site (447).

(5) Determine high-explosive QE by adding elevation plus site (469 mils).

(6) High-explosive deflection is 3,310 mils (chart deflection 3289 + drift L12 + GFT deflection correction: L9).

(7) Correct the HE data by applying the ballistic corrections from the addendum.

(a) From table A, extract the QE correction (-45.2 mils) and the deflection correction (R4.0) (fig 9-44).

(b) Enter table B with the HE fuze setting (35.7) (use lines 34.6 through 36.8), and extract a correction of -0.9.

(8) Complete, announce, and record the rest of the fire commands as shown in figures 9-42 and 9-43.

9-30. M422A1 COMPUTER PROCEDURES

The computer solution of firing data for the M422A1 and M424A1 projectiles cannot be determined. High-explosive data can be computed, and the ballistic corrections for shell nuclear are applied manually. Consult the job aids for specific instructions.

CHARGE 3	TABLE A		FT 8 ADD-H-1	FT 8 ADD-H-1	TABLE B																																																																																																																															
	QUADRANT ELEVATION		PROJ, ATOMIC, M422A1 FUZE, MT, M542	PROJ, ATOMIC, M422A1 FUZE, MT, M542	FUZE SETTING																																																																																																																															
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Figure 9-44. FT 8-Q-1, tables A and B.

Table 9-29. HE-to-nuclear charge correlation.

M109A2/A3 M114A1, M198	M114A1	M109A2/A3, M198
HE, M107 PROPELLANTS CHARGE	NUCLEAR PROJECTILE M454 PROPELLANTS CHARGE	NUCLEAR PROJECTILE M454 PROPELLANTS CHARGE
4 (GB or WB) 5 (GB or WB) 7 (WB)	1 (M206) 2 (M206) 3 (M207)	1 (M206) 2 (M206) 3 (M197)

9-31. 155-MM HOWITZER
NUCLEAR GUNNERY

The US nuclear inventory includes a 155-mm nuclear projectile in addition to the 203-mm nuclear projectiles. The 155-mm nuclear round consists of the atomic projectile M454; a propellant charge M206, M207, or M197; a sequential timer M32E1; and a fuze system that has MT and VT options. The VT fuze is armed by the sequential timer and has a high or low option that must be selected.

9-32. 155-MM NUCLEAR
DELIVERY
TECHNIQUES

Currently, K-transfer is the delivery technique for the 155-mm nuclear round. The firing data for this technique are determined to the same accuracy as data for conventional gunnery. With the K-transfer technique, an HE GFT setting is used to determine HE data to the target. These data are then modified for the nuclear round.

Note. Although the K-transfer technique is preferred, the met correction and observer adjustment techniques are still valid. For these techniques, use DA Form 4504 and DA Form 4505 (155-mm Nuclear Computation—Met Correction Technique).

a. Requirements. Use of the K-transfer technique requires a valid HE GFT setting. The target must be accurately located and must be within the GFT setting transfer limits. In applying HE corrections, the HE charge to nuclear charge correlation in table 9-29 is assumed.

b. Accuracy. The accuracy of the K-transfer technique depends on the validity of the GFT setting. Changes in weather will invalidate the GFT setting. A disadvantage of the K-transfer technique is the error induced by applying HE data in determining firing data for the nuclear projectile. Use of HE charges 4 and 5 green bag registration corrections is preferred to use of charges 4 and 5 white bag, because the differences between the standard muzzle velocities for M3A1 (GB) and M206 are less than the differences between M4A2 (WB) and M206.

9-33. MANUAL PROCEDURES
FOR SHELL NUCLEAR
BY USE OF THE GFT
AND TFT

When an GFT setting is determined and a nuclear mission is anticipated during the time that the GFT setting is valid, a nuclear standard GFT corrects the HE GFT to a standard projectile weight and a standard powder temperature. The nuclear standard GFT setting is used only when a nuclear mission is received.

EXAMPLE:

The following HE GFT setting was determined:

GFT A: Chg 4, Lot XY, Rg 5140, El 335, Ti 18.9 FT Df Corr: R5; Tot Df Corr: L2

The propellant temperature at the time the HE GFT setting was determined was +42° F.

The propellant weight of ammunition lot X is 6.

The lazy Z from the HE registration is as shown in figure 9-45.

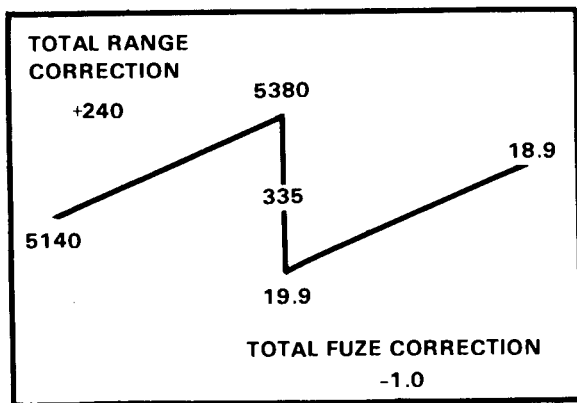


Figure 9-45. Lazy Z—HE registration.

a. The computer determines the corrected total range correction for a nuclear standard GFT setting.

(1) Steps used to correct a standard propellant temperature.

(a) To correct elevation to standard powder temperature, the computer enters table E of the HE TFT at the appropriate charge and range and extracts the effect on muzzle velocity due to propellant temperature at the time of the registration.

(b) The computer enters table F with chart range to the nearest 100 meters for the appropriate charge and range and extracts the range correction for a change in muzzle velocity of 1 meter per second (column 10 or 11).

(c) The computer multiplies the effect on MV due to propellant temperature by the range correction for a change in MV to determine a range correction value based on standard propellant temperature.

(2) Steps used to correct elevation to standard projectile weight.

(a) The computer determines the square weight difference between the registered projectile and the standard weight.

(b) The computer enters table F with the GFT range and extracts the range correction to correct for a change of 1 square weight.

(c) The computer multiplies the range change for a square weight difference of 1 square by the square weight change.

(3) The computer adds the range correction determined for powder temperature to the range correction determined for projectile weight and expresses this value to the nearest 10 meters.

(4) The computer then adds the total range correction value determined in paragraph (3) above to the total range correction determined from the lazy Z in the registration and begins to build a nuclear standard GFT setting.

b. The computer determines the corrected total fuze correction for a nuclear standard GFT setting.

(1) Steps used to correct time to standard propellant temperature.

(a) The computer enters table J with the corrected time determined in the lazy Z (fig 9-45) and extracts correction factors for muzzle velocity and projectile weight.

(b) The computer multiplies the MV correction factors by the change to muzzle velocity determined in paragraph (a) above.

(2) Steps used to correct time to standard for projectile weight.

(a) The computer multiplies the fuze correction factor by the change in projectile weight to determine the fuze correction factor for projectile weight.

(b) The computer adds the fuze correction factor for propellant temperature to the fuze correction factor for projectile weight expressed to the nearest tenth. This value is the total fuze correction.

(c) The computer now adds the total fuze correction value to the total fuze correction determined from the lazy Z in the registration and completes the nuclear standard GFT setting.

(d) The computer records the nuclear standard GFT setting.

9-34. NUCLEAR FIRE MISSION PROCESSING

When a nuclear fire mission is received, the firing data are computed by use of the nuclear standard GFT setting to determine HE data.

Ballistic corrections are then applied by use of FT 155-AJ-2.

a. Upon receipt of a nuclear fire mission, the FDO issues his fire order on the basis of the information in the classified message.

b. The HCO determines and announces chart data to the target. The VCO determines site.

c. The computer announces initial fire commands.

d. The executive officer reports the nuclear propellant temperature and the nuclear projectile weight.

e. The computer determines the range correction for nuclear propellant temperature.

(1) The computer enters FT 155-AJ-2, table E, and extracts the effect of propellant temperature on muzzle velocity.

(2) The computer enters table F with the appropriate change and range to the target and extracts from column 10 or 11 the range correction for a change in muzzle velocity of 1 meter per second.

(3) The computer multiplies the effect on muzzle velocity due to propellant temperature by the change in range for a change in muzzle velocity of 1 meter per second. This determines the range correction compensating for nuclear propellant temperature.

f. The computer determines the range correction for nuclear projectile weight.

(1) The computer determines the difference between a standard nuclear

projectile (120.4 pounds) and the nuclear projectile to be fired.

(2) The computer enters FT 155-AJ-2, table F, with range to the target and extracts from column 18 or 19 the meter correction for a 1-pound difference in projectile weight.

(3) The computer multiplies the projectile weight difference by the correction value of a 1-pound weight difference.

g. The computer determines the total range correction to compensate for projectile weight and propellant temperature.

h. The computer adds the total range correction to the range to the target.

i. The computer now determines HE data by use of the nuclear standard GFT setting and the corrected range.

j. The computer enters table O with the high-explosive QE and extracts and applies ballistic corrections to HE time, deflection, and quadrant.

k. The computer enters table K with the nuclear propellant temperature and the intermediate time setting and extracts a temperature correction to the nuclear fuze.

Note. If the mission called for fuze time in effect rather than fuze VT, the corrected time setting would be the time fired.

l. The computer enters table L with the corrected time setting and the temperature of the time fuze (nuclear propellant temperature) to determine the backoff time for firing the nuclear fuze with the VT option.

Section V COPPERHEAD

9-35. CHARACTERISTICS

a. The cannon-launched guided projectile (M712 Copperhead) is a high-explosive antitank 155-mm projectile. It is significantly heavier (137 pounds) and

longer (54 inches) than the standard 155-mm high-explosive projectile. The nose of the projectile houses a semiactive laser seeker in a clear plastic cone. The body contains fins and wings, which deploy in flight and allow the round to maneuver. The projectile

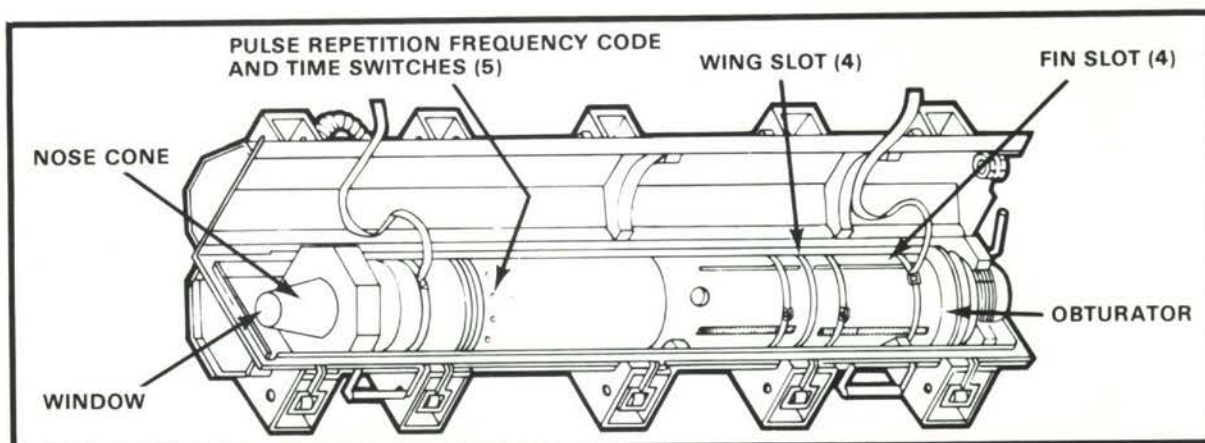


Figure 9-46. Copperhead projectile in shipping configuration.

requires no special assembly or testing at the firing site. The projectile is shipped and stored in a sealed container (fig 9-46).

b. The Copperhead round can be fired in either the ballistic mode or the glide mode. The primary mode, for use in the minimum to intermediate gun-target ranges, is the ballistic mode. The projectile flies on a purely ballistic trajectory similar to that of a conventional artillery round until it reaches a point on the descending branch of its trajectory. At that point, the laser designator operator is cued to begin designating the target. The Copperhead projectile acquires the reflected laser energy and initiates the internal guidance and control that allow it to maneuver to and hit the designated target. In the intermediate to maximum ranges, the Copperhead projectile flies in the glide mode. In the glide mode, the round flies on a ballistic trajectory to a point just beyond the maximum ordinate. The projectile, using its internal gyro as an inertial reference, maintains a constant flyout angle (356 or 444 mils). This is the angle of fall. The projectile maintains this angle of fall until impact. This mode allows the projectile to fly under low cloud cover and to fly out to extended ranges not achievable in the ballistic mode.

c. The ground surface area in which the round can maneuver is limited. The optimum limit of maneuverability of the Copperhead round is called a footprint. The size of the footprint is determined with respect to the ballistic aimpoint. This aimpoint is the point on the ground where the Copperhead round

would impact if it did not maneuver. The ballistic aimpoint is on the gun-target line, usually short of the target location sent in by the observer. The distance that the ballistic aimpoint is short of the target location varies and is called the offset correction. This offset distance is used to ensure that the maximum probability of hit occurs at the original target location sent in by the observer. The larger the target location error, the lower the probability of hitting the target (fig 9-47).

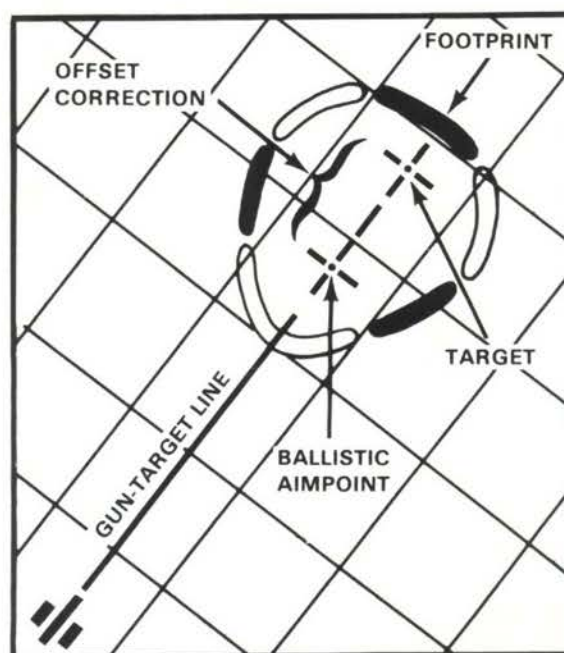


Figure 9-47. Copperhead footprint and offset correction.

d. Copperhead missions, like conventional missions, can be fired on either planned targets or targets of opportunity.

(1) **Planned targets.** Firing on planned targets (fig 9-48) achieves faster response times. Planned targets fall into two categories.

(a) *Priority targets.* For priority targets, data are precomputed and set on the guns. The Copperhead round is prepared and placed in or near the howitzer. Unless otherwise specified on the target list, two Copperhead rounds are prepared in advance for each Copperhead priority target.

(b) *On-call targets.* On-call targets for Copperhead are handled in the same manner as those for conventional missions. Firing data will be held at the FIST and sent to TACFIRE/BCS for processing as priority targets or targets of opportunity.

(2) **Targets of opportunity.** A Copperhead target of opportunity is processed in nearly the same manner as a target of opportunity for conventional munitions. Since the FDC cannot begin to compute firing data until the call for fire is received, this method of engaging a target with Copperhead has a slower response time than that for planned targets.

9-36. COMPUTATIONS FOR SHELL COPPERHEAD

a. Firing data for Copperhead targets can be computed manually, with the BCS, or with FADAC.

b. When a Copperhead target list is received (voice) from the battalion FDC, priority targets are processed first. Firing data are sent to the guns assigned to each priority target (normally one platoon per target) and recorded in the battery FDC. The guns prepare rounds and lay on these data between other missions until otherwise directed by the FDC. Firing data for the rest of the Copperhead target list are then computed and recorded, by target number, in the fire direction center.

c. The target locations for all planned Copperhead targets are stored in FADAC or in the battery computer system. All Copperhead firing data are updated (priority targets first) as changes in weather and other factors occur. Battery FDCs should know how to use the Copperhead footprint template and should know about the 800-mil angle T requirement.

d. The observer must know when the battery is prepared to fire on his targets. Response time will be excessive if the

TARGET NO	TARGET LOCATION	OBSERVER	PRIORITY (✓-YES)	FIRE (✓-YES)	PLATOONS TO FIRE	NO OF ROUNDS PLANNED	CHG	TRAJECTORY	SWITCH SETTING	DEFLECTION	QE	TOF	DESIGNATE TIME
AB2210	3522 4021	T18	✓		R	5	5GB	BAL	11333	3041	371	20	4
AB2211	3518 4092	T18			C	3	5GB	BAL	12333	3186	383	21	4
AB2212	3617 4122	T18			L	2	5GB	BAL	12383	3217	408	22	5
AB2213	3655 4144	T18			R	4	5GB	BAL	13333	3262	431	24	7
AB2240	3728 4017	J24	✓		C	6	6WB	BAL	12421	2977	343	22	6
AB2241	3790 4044	J24			L	2	6WB	BAL	1344	2315	374	24	8
AB2242	3805 4151	J24			R	2	6WB	BAL	13421	2853	404	25	9
AB2243	3842 4175	J24			C	2	6WB	BAL	14421	2791	438	27	11
AB2270	3922 4141	N57	✓		L	6	7WB	GLIDE(35M)	51274	2604	471	38	19
AB2271	3975 4208	N57			R	4	7WB	GLIDE(35M)	52274	2508	416	39	20
AB2272	4055 4255	N57			C	2	7WB	GLIDE(35M)	52274	2501	518	42	23
AB2273	4166 4227	N57			L	2	7WB	GLIDE(35M)	53274	2488	561	46	27

Figure 9-48. Sample Copperhead planned target chart.

Copperhead rounds and the guns are not prepared in advance. The FDC transmits the message to observer and the ready message to tell the observer that the unit is prepared to fire on the priority target at any time thereafter. If target priorities change during the battle, the firing unit must change the data on the guns and the rounds quickly to provide continued support. If the mission is processed through TACFIRE, the battery FDC does not need to send an MTO.

9-37. MISSION PRIORITY

Copperhead missions take priority over conventional missions unless the tactical situation or commander's guidance dictates otherwise. A firing unit may have both a planned priority Copperhead mission and an FPF mission. The firing platoon identified for the Copperhead mission is laid on the Copperhead data, while the rest of the battery is laid on FPF data. Once the attacking forces pass the Copperhead mission location or get close to friendly defensive positions (within 1,000 to 1,500 meters of FPF data or known observer locations), the FDC should automatically have the entire battery lay on assigned FPF data between fire missions. Normally, the Copperhead target will not have higher priority than the FPF once the enemy is within 1,000 to 1,500 meters. Therefore, it is important for the FDC to keep accurately abreast of the overall tactical situation at all times.

Note. Remember, the maneuver commander's guidance may override the general rules in this publication.

9-38. COPPERHEAD SOP

Unit SOPs dealing with Copperhead missions are helpful in rapidly disseminating mission-essential information with a minimum of discussion. When used with extensive training, good unit SOPs can result in more streamlined fire missions.

9-39. VOICE CALLS FOR FIRE

a. An observer requesting Copperhead fires will send a call for fire to the battery

FDC over an established fire net. Calls for fire are sent to request fires on both planned targets and targets of opportunity.

b. A voice call for fire for planned targets contains the following elements:

ELEMENT	EXAMPLE
Observer identification	THIS IS Y4A71
Warning order	FIRE TARGET AY4781, OVER
Target description	FOUR TANKS
Method of engagement	5 ROUNDS
Method of control	AT MY COMMAND, OVER

(1) If the number of rounds to fire is not specified in the call for fire, the FDC will fire the number of rounds specified for that target on the Copperhead target list. If the number of rounds is not specified on the target list, the FDC will fire two rounds at the target.

(2) When the observer requests **AT MY COMMAND**, the Copperhead rounds will be fired at intervals of at least 20 seconds after the observer gives the command to fire. The exact interval is established by the FDO in his fire order or by unit SOP. When **BY ROUND AT MY COMMAND** is requested, the observer will control the firing of each Copperhead round.

(3) To enhance mission responsiveness when engaging priority targets, the observer may omit the target description, method of engagement, and method of control.

c. The FDC will fire the Copperhead rounds at intervals of at least 20 seconds after firing the first round.

d. Calls for fire for targets of opportunity follow the same format as the standard call for fire.

ELEMENT	EXAMPLE
Observer identification	Y5A57, THIS IS Y4A71
Warning order	FIRE FOR EFFECT, POLAR, OVER

Location of target	DIRECTION 1800, DISTANCE 3450, VERTICAL ANGLE +5, OVER
Target description	TWO TANKS
Method of engagement	COPPERHEAD, 3 ROUNDS
Method of control	BY ROUND, AT MY COMMAND, OVER

9-40. MESSAGE TO OBSERVER (AUTONOMOUS)

a. After a call for fire has been received and mission processing has started, an MTO is sent as soon as possible before firing.

b. The MTO for Copperhead missions includes the following elements:

ELEMENT	EXAMPLE
Unit firing	A3Q27
Number of rounds	3 ROUNDS
Laser pulse repetition frequency code	CODE 241
Time of flight	TIME OF FLIGHT

c. If the battalion FDC is in tactical control, it will send the MTO for planned targets.

9-41. LASER PULSE REPETITION FREQUENCY CODE

For a Copperhead mission to be successful, the three-digit PRF code set on the Copperhead round must match the PRF code set on the observer's G/VLLD. The FDCs are given a list of all observer PRF codes by call sign. One PRF code is indicated as primary for each observer. The FDC selects the proper PRF code on the basis of the observer's identification in the call for fire and sends it to the guns, where it is placed on the Copperhead round. If the FDC sends the observer a different code in the MTO than the one set on the G/VLLD, the observer will change the PRF code on his G/VLLD to match the code sent by the fire direction center.

9-42. FIRE ORDER

a. The elements set to standard are not addressed unless a change to the standard is desired.

b. Normally, a single platoon will handle a given Copperhead fire mission. If the tactical situation permits, the FDO, in his fire order, may specify more than one platoon to fire a Copperhead mission to facilitate attack of the target.

9-43. COMPUTATION OF FIRING DATA

a. Initial Chart Data. The computation of firing data for Copperhead begins with determining chart data. This applies to both planned targets (target locations are taken from the Copperhead target list) and targets of opportunity (target locations are provided in the call for fire). The initial chart data required for Copperhead missions are chart range, chart deflection, and angle T. Normally, chart data are determined by the HCO in a manual fire direction center and by the VCO in a manual/FADAC fire direction center.

b. Charge and Trajectory Selection. Given the chart range to the target, the FDO or chief computer enters the Copperhead charge selection table (table 9-30) in the Copperhead TFT (FT 155-AS-0) under the appropriate weapon system. The charge and trajectory to fire are determined by identifying the range interval for a listed charge that includes the chart range. For example, the charge for chart range 5630 is charge 5GB. The ballistic mode trajectory is selected. If the chart range falls exactly on the range changeover point for two charges, the lower charge and corresponding trajectory are selected. The selected charge is then announced to the computer.

Notes. 1. Copperhead trajectories are explained later in this section.

2. It is important that the range intervals for each listed charge be strictly adhered to, since firing outside these intervals may significantly degrade Copperhead's performance.

Table 9-30. Copperhead charge selection.

RANGE (KM)		MODE	CHARGE			TARGET CLOUD HEIGHT MINIMUMS	FOOTPRINT CODE
FROM	TO		M3A1	M4A2	M119A1		
Low-Angle M109A1 and M109A1B Howitzers:							
3.0	4.6	ballistic	④	4		10% of range	A
4.6	5.8	ballistic	⑤	5		10% of range	B
5.8	7.2	ballistic		⑥		10% of range	C
7.2	8.8	ballistic		⑦		10% of range	D
8.8	9.5	glide (356 mils)		⑥		750 meters	E
9.5	11.6	glide (356 mils)		⑦		600 meters	F blue
						750 meters	H green
11.6	13.0	glide (444 mils)		⑦		900 meters	G
Low-Angle M109A2, M109A3, and M198 Howitzers:							
3.0	4.6	ballistic	④	4		10% of range	A
4.6	5.8	ballistic	⑤	5		10% of range	B
5.8	7.2	ballistic		⑥		10% of range	C
7.2	8.8	ballistic		⑦		10% of range	D
8.8	9.5	glide (356 mils)		⑥		750 meters	E
9.5	11.0	glide (356 mils)		⑦		600 meters	F
11.0	13.2	glide (356 mils)			⑧	600 meters	H blue
						750 meters	H green
13.2	16.8	glide (444 mils)			⑧	900 meters	J
High Angle—All Weapon Systems:							
5.0	6.5	ballistic	⑤	5		2,120 meters	K
6.5	8.0	ballistic		⑥		2,120 meters	L
8.0	9.5	ballistic		⑦		2,120 meters ¹	M
9.5	11.6	ballistic			⑧	2,120 meters	N
¹ M109A2, M109A3, and M198 howitzers only.							
○ Preferred charge.							

9-44. ANGLE T AND TARGET CLOUD HEIGHT CHECK

a. The angle T check, by either the FDO or the chief computer, is made by listening to the announced angle T and determining whether it meets the angle T requirement for Copperhead (800 mils or less). Copperhead should not be fired when the angle T is greater than 800 mils. An angle T of this magnitude may seriously degrade the

round's ability to successfully acquire and engage its intended target.

b. The target cloud height check is made by computing the target cloud height, expressing it to the nearest 50 meters, and comparing it with the minimum cloud height requirement for the charge selected. The target cloud height can be computed in one of two ways, depending on the method used to locate the target.

(1) If the target is located by grid coordinates, the observer altitude is added to the observer cloud height to obtain the cloud altitude. The target altitude (taken from a map) is then subtracted from the cloud altitude to determine the target cloud height.

EXAMPLE:

Observer cloud height	740 meters
Observer alt	+ 460 meters
Cloud alt	= 1,200 meters
Target alt	- 355 meters
Target cloud height	= 845 meters
	≈ 850 meters

(2) If the target is located by laser polar plot, as will normally be the case of targets of opportunity, compute the target cloud height as follows: First, using the OT distance and vertical angle reported by the observer, compute the observer-target vertical interval (OT VI) by use of the C- and D-scales of the graphical site table. Then add OT VI to the observer altitude to determine the target altitude. Compute the cloud altitude by adding the observer altitude to the observer cloud height. Determine target cloud height by subtracting the target altitude from the cloud altitude.

EXAMPLE:

OT distance	3340 meters
Vertical angle	-32
OT VI	-105 (from GST)
Observer alt	460 meters
Observer cloud height	740 meters
Target alt = observer alt + OT VI = 460 + (-105) = 355	
Cloud alt = observer cloud height + observer alt = 740 + 460 = 1200	
Target cloud height = cloud alt - target alt = 1200 - 355 = 845 ≈ 850	

Notes. 1. In a manual FDC, the VCO normally computes the target cloud height and reports it to the FDO or chief computer.

The FDO/chief computer then checks the minimum target cloud height requirement. In a manual/FADAC fire direction center, the FDO/chief computer normally performs all functions associated with the target cloud height check when data are computed manually. When data are computed with FADAC/BCS, the computer automatically checks the target cloud height.

2. An OT VI of less than ± 30 meters can be ignored for targets of opportunity. In such cases, target cloud height equals observer cloud height.

3. When the target cloud height is below the minimum required for the selected charge, Copperhead rounds should not be fired. Insufficient target cloud height will adversely affect the accuracy of Copperhead rounds.

9-45. DETERMINATION OF THE RANGE OFFSET CORRECTION

a. To facilitate Copperhead's ability to home in on the target, the computer applies a range offset correction to the chart range (tables 9-31 and 9-32). He obtains the range offset correction by entering the range offset table in the Copperhead TFT for the mode to be fired with chart range expressed to the nearest 100 meters.

Table 9-31. Range offset—ballistic mode (low angle).

CHART RANGE (METERS)	RANGE OFFSET CORRECTION (METERS)
3,000	0
3,100	-50
3,200	-100
3,300	-150
3,400	-200
3,500	-250
3,600	-300
3,700	-350
3,800	-400
3,900	-450
4,000 and beyond	-500
Chart range = 5,630 ≈ 5,600 meters	
Range offset correction = -500	

Table 9-32. Range offset—glide mode.

MODE	CHART RANGE (METERS)	RANGE OFFSET CORRECTION (METERS)
Glide—356 Mils ¹	6,000 and above	0
Glide—444 Mils ²	6,000 and above	-300

¹Do not fire with cloud ceiling below 600 meters.

²Do not fire with cloud ceiling below 900 meters.

b. When the computer applies the range offset correction to the chart range, the result is the offset chart range.

EXAMPLE:

Chart range	5,630 meters
Range offset correction	(+) <u>-500 meters</u>
Offset chart range	5,130 meters

c. The offset chart range serves as the entry argument for table F of the Copperhead tabular firing table. It is also the range used

to determine firing data from the Copperhead graphical firing tables and site from the Copperhead graphical site table.

9-46. TRAJECTORIES

a. Low-Angle Ballistic Mode. The primary mode for the minimum to intermediate gun-target ranges is the low-angle ballistic mode (fig 9-49). The projectile travels in a purely ballistic trajectory similar to that of a conventional artillery round until it reaches a point on the descending branch of its trajectory. At that

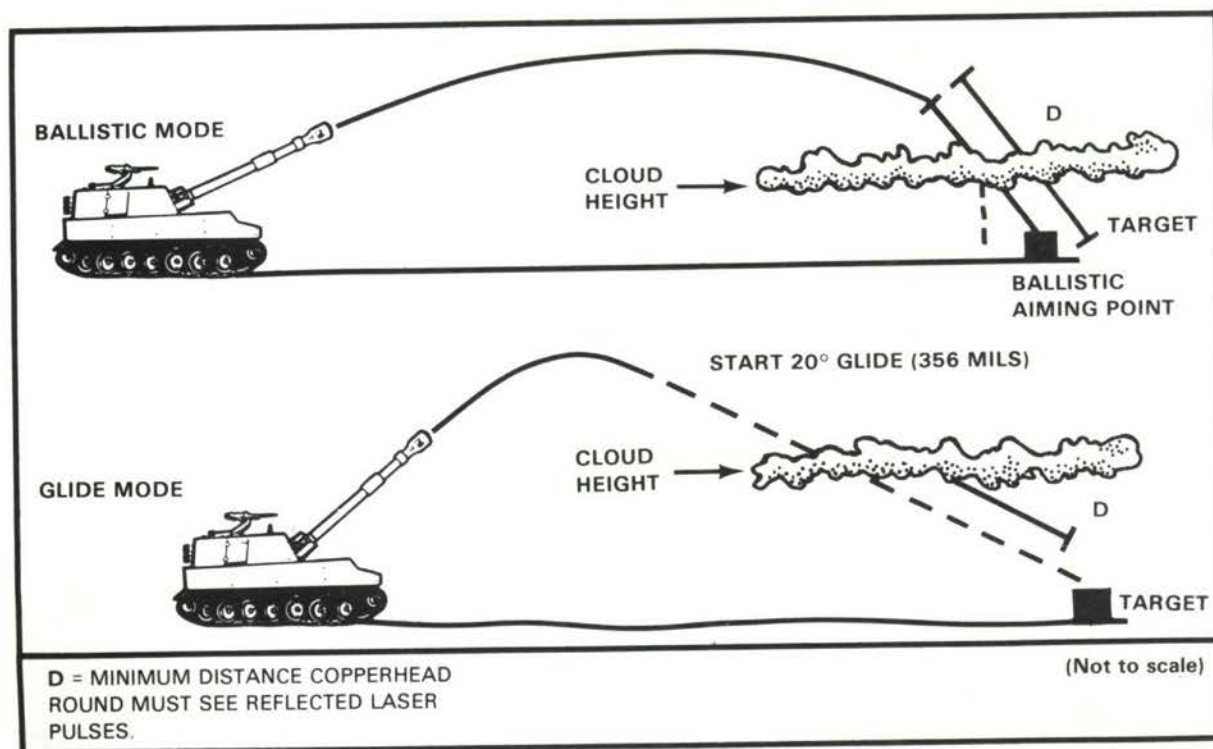


Figure 9-49. Comparison of low-angle ballistic and glide mode trajectories.

point, the observer has begun designating the target with the G/VLLD. The Copperhead projectile acquires the reflected laser energy and initiates internal guidance and control that allow it to maneuver to the target.

b. Glide Mode. From the intermediate to maximum ranges, the Copperhead projectile travels in the glide mode (fig 9-49). In the glide mode, the projectile travels in a ballistic trajectory to a point just beyond the maximum ordinate. Here the projectile, using its internal gyro as an inertial reference, maintains a constant angle of fall (356 or 444 mils). The projectile maintains this angle of fall until laser acquisition. The glide mode allows the projectile to fly out to extended ranges not achieved in the low-angle ballistic mode.

c. Firing Tables. Tabular and graphical firing tables have been produced to help the computer manually determine firing data for the different Copperhead trajectories. The GFTs are based on the range intervals outlined in the charge selection table.

d. High-Angle Fire. Firing Copperhead high angle will be discussed later in this chapter.

Note. The examples of the TFT, GFT, and GST from this point on may show different values than the actual fielded TFT, GFT, and GST. The examples used in this section are intended to stress format and procedures only.

9-47. DESCRIPTION OF M712 LOW-ANGLE BALLISTIC GFT

a. The basic design of the Copperhead low-angle ballistic GFT (fig 9-50) is similar to that of low-angle GFTs for conventional munitions. The scales appearing on the rule from top to bottom are as follows:

(1) **Range scale.** The range scale is the base scale. Range is expressed logarithmically, in meters, and varies for each charge. It increases from left to right and is read to the nearest 10 meters.

(2) **Elevation scale.** The elevation scale increases from left to right and is graduated in mils. It is read to the nearest mil.

(3) **Time-setting scale.** The time-setting scale provides the first two digits of the five-digit switch setting sent to the guns. The last three digits are the PRF code. If a reading falls exactly on the changeover point between two time settings, the higher time setting will be used.

(4) **Designate time scale.** The FDC sends **DESIGNATE** to the G/VLLD operator approximately 20 seconds before impact. The operator must designate the target during the last 13 seconds of time of flight. The designate time scale indicates the maximum time the FDC can wait after the round is fired to send **DESIGNATE** and still allow the G/VLLD operator to designate the target. If a reading falls exactly on the changeover point between two designate times, the lower value will be used.

(5) **Time-of-flight scale.** The time-of-flight scale indicates the time to impact after the Copperhead round is fired. It is graduated in tenths of a second and is read to the nearest whole second.

b. Some Copperhead GFT settings reflect extremely large total range corrections. To facilitate applying these settings to the GFT, the Copperhead low-angle ballistic cursor was produced without a manufacturer's hairline. A range gage line is drawn parallel to the RG K line at any convenient location on the cursor to read data from the low-angle ballistic GFT. All data are read from the constructed elevation gage line.

9-48. LOW-ANGLE BALLISTIC GFT SETTING

a. Registrations are not fired with the Copperhead round. Also, ballistic differences between HE and Copperhead will not permit the use of HE low-angle GFT settings with Copperhead. Therefore, Copperhead low-angle ballistic GFT settings are based only on met, propellant temperature, and muzzle velocity corrections. They are obtained through FADAC/BCS (preferred) or by use of subsequent met procedures to manually solve a met. When manually solving a met for Copperhead, apply the following guidelines:

(1) Use a position deflection correction of 0.

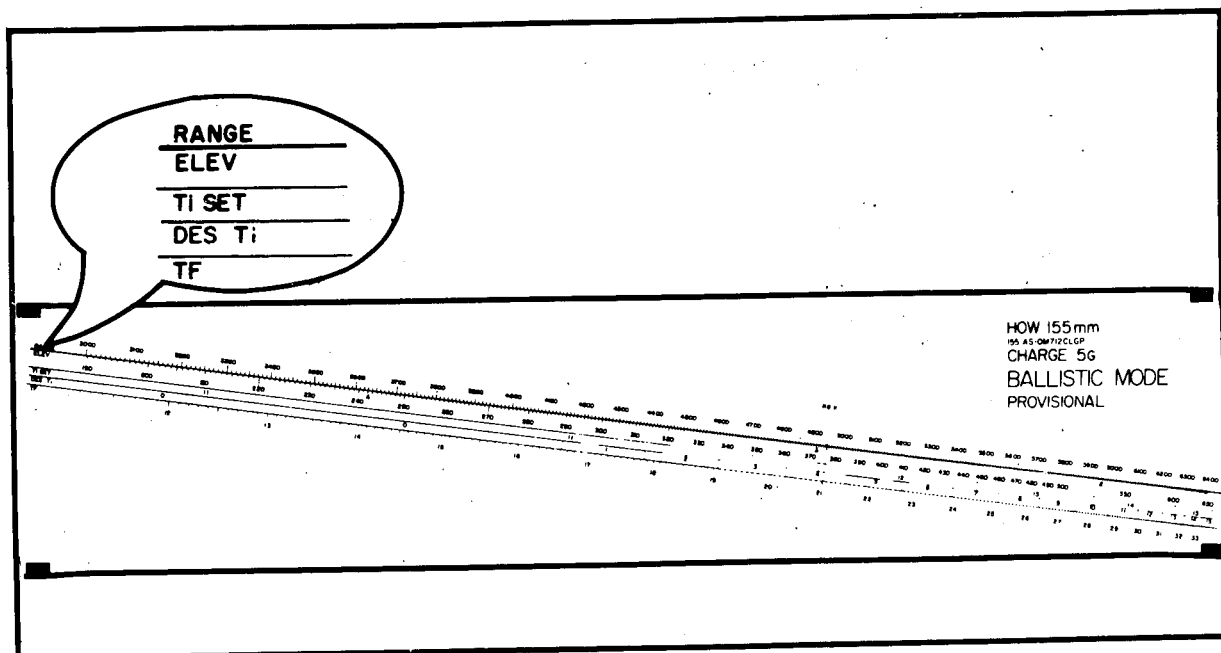


Figure 9-50. Copperhead low-angle ballistic GFT.

(2) Use muzzle velocity variation (MVV) calibration data determined from the M90 velocimeter as the position velocity error.

Note. An MVV for Copperhead determined by calibration may not be available. When tube wear data become available for Copperhead, the loss in muzzle velocity due to tube erosion as determined from a recent pullover gage reading or from equivalent full charge rounds will be used as the position velocity error. A position velocity error of 0 will be used in the absence of calibration data for Copperhead. Manually derived GFT settings apply to the ballistic mode only. Examples are in the TFT.

(3) Total fuze setting corrections are not computed.

b. If time permits, multiplot GFT settings should be computed for the low-angle ballistic GFT. This is especially important when working with charges 6WB and 7WB. The ranges used to compute the multiplot GFT settings should come from the upper, middle, and lower thirds of the range interval for the charge. Use met check gage points if they are available.

Table 9-33. Preferred ranges for one-plot Copperhead GFT settings in the low-angle ballistic mode.

CHARGE	OFFSET CHART RANGE (METERS)	CORRESPONDING CHART RANGE (METERS)
4GB or 4WB	3,550	4,050
5GB or 5WB	4,700	5,200
6WB	6,000	6,500
7WB	7,500	8,000

c. When time does not permit the computation of multiplot GFT settings, one-plot GFT settings should be computed. One-plot GFT settings provide acceptable accuracy for the computation of firing data. The degree of accuracy for one-plot GFT settings is higher for charges 4GB/WB and 5GB/WB than for charges 6WB, 7WB, and 8. The ranges at which one-plot GFT settings should be computed are shown in table 9-33.

Note. When GFT settings are determined by manually solving a met, the range used must be converted to an offset chart range. When FADAC/BCS is used to derive GFT settings, the uncorrected chart range is entered. FADAC/BCS automatically applies the range offset correction. The derived GFT setting is then applied on the GFT at the offset chart range. In all cases, the range listed in the GFT setting is the offset chart range.

d. A low-angle ballistic GFT setting contains the following information:

- (1) Unit.
- (2) Charge.
- (3) Trajectory (for example, low-angle ballistic [LA bal]).
- (4) Ammunition lot.
- (5) Range (offset chart range).
- (6) Elevation.
- (7) GFT deflection correction.

EXAMPLE:

GFT A: Chg 5, LA Bal, Lot RY, Rg 4700, El 357; GFT Df Corr: R3.

9-49. TRANSFER LIMITS

A Copperhead low-angle ballistic GFT setting is valid for the range interval specified for the charge in the charge selection table. The GFT setting is also valid 400 mils left and right of the azimuth of fire for which it was computed. Accuracy of the firing data will, however, degrade rapidly as the transfer limits are approached.

9-50. APPLICATION OF THE GFT SETTING

The procedures for applying the GFT setting to the GFT are explained below. Use the following low-angle ballistic GFT setting:

GFT B: Chg 5, LA Bal, Lot RY, Rg 4700, El 361; GFT Df Corr: L2.

- STEP 1. Place the constructed range gage line over range 4700 on the range scale.
- STEP 2. Place a pencil mark on elevation 361 on the elevation scale.
- STEP 3. Slide the cursor so that the pencil mark is over the RG K line.
- STEP 4. Construct the elevation gage line by drawing a line through the pencil mark parallel to the RG K line.
- STEP 5. Place the constructed range gage line over range 4700 to verify that elevation 361 is read under the elevation gage line.
- STEP 6. Enter the GFT deflection correction on the upper right-hand corner of the cursor.

Note. The location of the range gage line may have to be adjusted to accommodate placement of the elevation gage line.

9-51. DATA READ FROM THE LOW-ANGLE BALLISTIC GFT

To read data from the low-angle ballistic GFT with a GFT setting applied (fig 9-51), place the range gage line over the offset chart range. Read elevation, time setting, designate time, and time of flight under the elevation gage line.

EXAMPLE:

Offset chart range	5110
Elevation	413
Time setting	12
Designate time	6
Time of flight	23

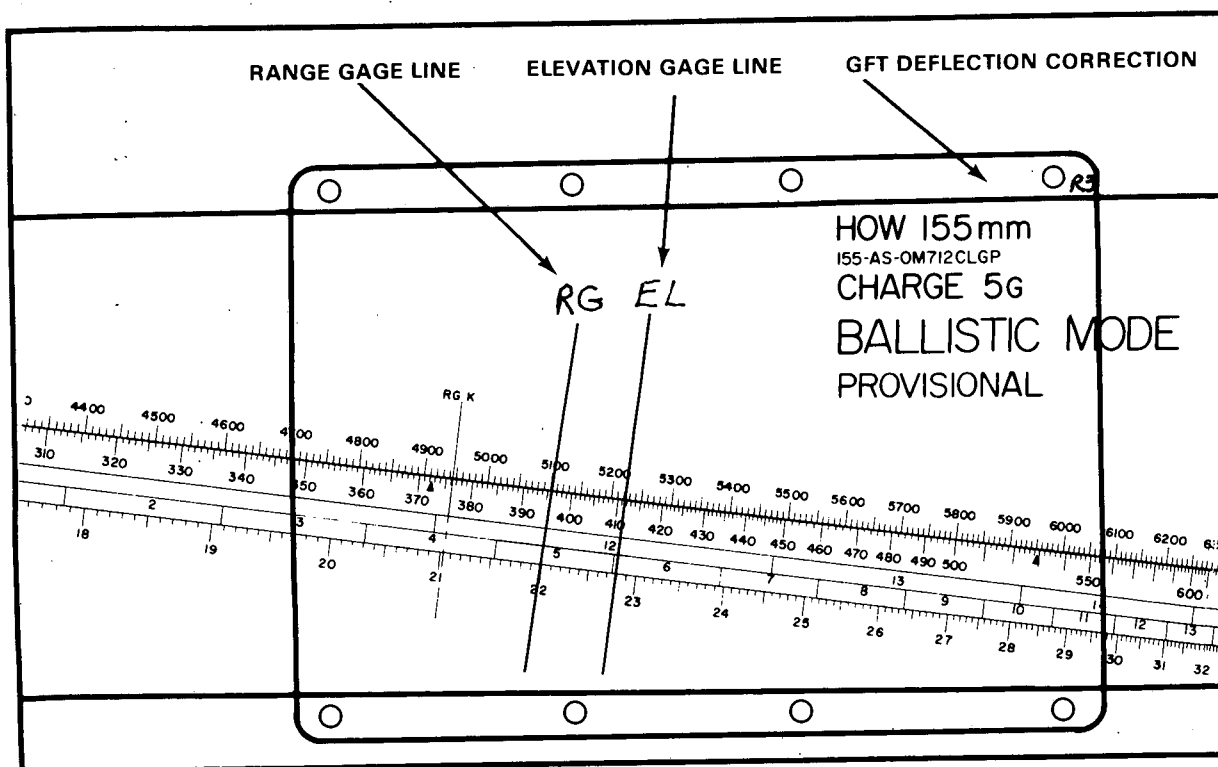


Figure 9-51. M712 low-angle ballistic GFT with GFT setting applied.

9-52. M712 LOW-ANGLE GLIDE MODE GFT

a. The Copperhead glide mode GFT (fig 9-52) allows the FDC to compute data for Copperhead in the glide mode. Because of the limited accuracy of the manual solution, firing data computed by FADAC or BCS should be used whenever possible.

b. The organization of the Copperhead glide mode GFT differs from that of the ballistic mode GFT. At the top of a glide mode GFT is a common range scale. Beneath the range scale are time-setting groups. Each group has its own elevation, time-of-flight, and designate time scales. The time-setting groups are color-coded alternately red and blue to help identify the scales belonging to each group.

c. Charges 7WB and 8 have glide mode GFTs for the 356-mil (20°) and 444-mil (25°) glide angles. Charge 6WB has a glide mode GFT for the 356-mil (20°) glide angle only.

d. As with the low-angle ballistic GFT, there is no MHL on the cursor. A range gage line has been drawn parallel to the RG K line at a convenient location on the cursor. This was done to facilitate applying GFT settings with extremely large total range corrections.

9-53. DETERMINATION OF THE TIME SETTING

The clear area within each time-setting group is used in conjunction with the constructed range gage line to determine the time setting to be fired. This is done by placing the range gage line over the offset chart range (fig 9-52). The clear area intersected by the range gage line determines the time setting and time-setting group to be used in computing firing data. If the range gage line lies exactly between the clear areas of two time-setting groups, the numerically higher time setting and time-setting group will be used.

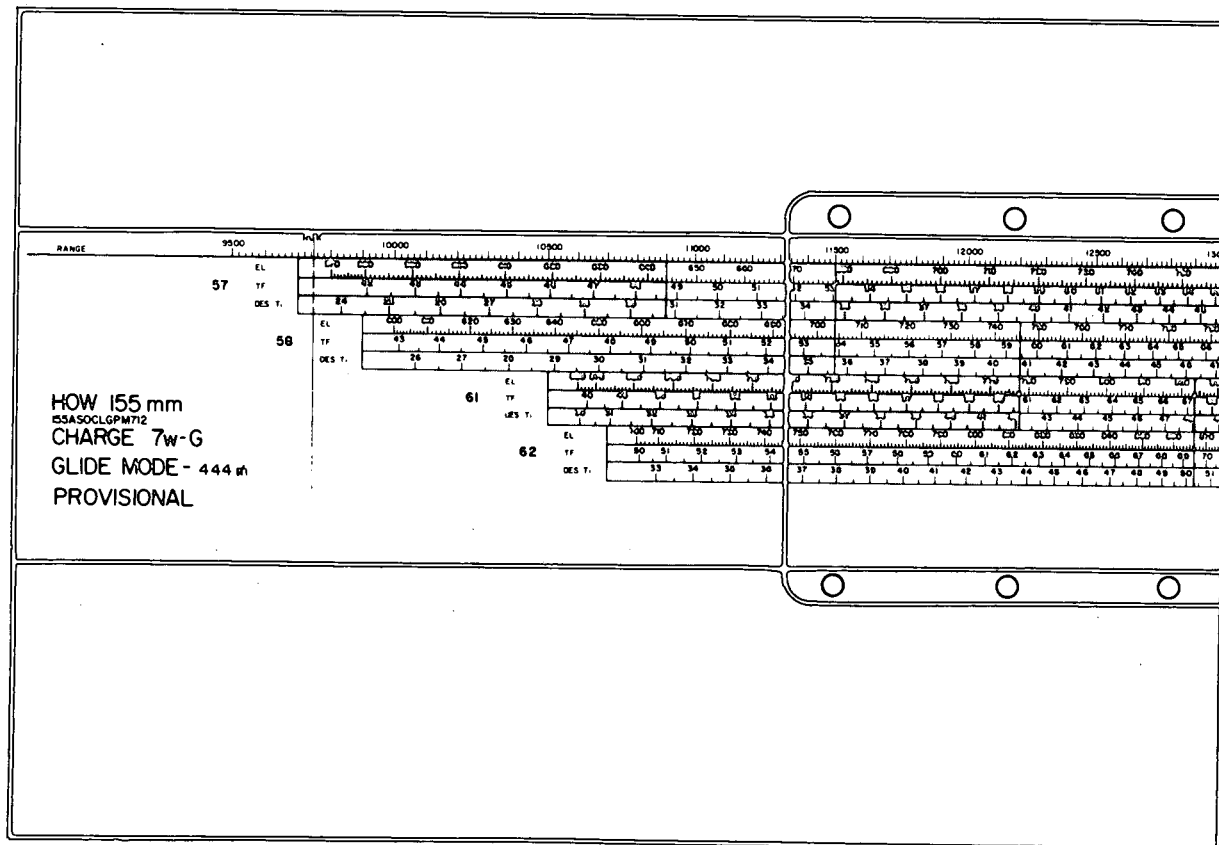


Figure 9-52. M712 low-angle glide mode GFT.

9-54. DETERMINATION OF ELEVATION, TIME OF FLIGHT, AND DESIGNATE TIME

Elevation, time of flight, and designate time are all read under the elevation gage line for the selected time-setting group.

Note. Under uncertain conditions, the FADAC may compute glide mode firing data that differ from the manual solution firing data. In these cases, the computer solution should always be used. Computer-determined firing data (FADAC or BCS) should always be used when actually firing Copperhead in the glide mode during training.

9-55. GLIDE MODE TRANSFER LIMITS

The Copperhead glide mode GFT setting is valid for the range interval specified for the charge and glide angle in the charge selection table. Deflection transfer limits are 200 miles left and right of the azimuth of fire for which the GFT setting was computed. Accuracy of the firing data degrades rapidly as the transfer limits are approached.

9-56. GLIDE MODE GFT SETTING

a. Graphical firing table settings must be applied before firing data are extracted from

the Copperhead glide mode graphical firing table. *The Copperhead glide mode GFT is never used without a GFT setting.* Glide mode GFT settings are always derived from FADAC or other computer systems such as the BCS or TACFIRE. Glide mode GFT settings cannot be obtained by manually solving a met or with a programable handheld calculator, since these methods are based on purely ballistic trajectories only.

b. One-plot GFT settings are computed for glide mode graphical firing tables. The ranges at which FADAC or BCS GFT settings for Copperhead glide mode GFTs are computed are listed in table 9-34 for the charges and glide angles.

Notes. 1. The glide mode offset range correction for all 356-mil glide angles is 0. The offset range correction for all 444-mil glide angles is -300 meters.

2. The chart ranges listed in table 9-34 are converted to offset chart ranges before the derived GFT setting is applied to the GFT.

c. A glide mode GFT setting contains the following information:

- (1) Unit.
- (2) Charge.
- (3) Glide angle trajectory (for example, 356 miles glide).
- (4) Ammunition lot.
- (5) Range (offset chart).

Table 9-34. Ranges for GFT settings.

CHARGE	WEAPON	GLIDE ANGLE 356 MILS CHART RANGE (METERS)	GLIDE ANGLE 444 MILS CHART RANGE (METERS)
6WB	All	9,150	NA
7WB	M109A1	10,500	12,300
	M109A1B		
7WB	M109A2	10,250	NA
	M109A3		
	M198		
8	M109A2	12,100	15,000
	M109A3		
	M198		

- (6) Time-setting group.
- (7) Elevation.
- (8) GFT deflection correction.

EXAMPLE:

GFT C: Chg 7, 356 Mils Glide, Lot RT, Rg 10,500, Time-Setting Group 52, El 512; GFT Df Corr: R5.

d. Using the example glide mode GFT setting shown above, apply the GFT setting to the glide mode GFT as outlined in figure 9-53.

- STEP 1.** Place the constructed range gage line over range 10,500 on the range scale.
- STEP 2.** Place a pencil mark at elevation 512 on the elevation scale of time-setting group 52.
- STEP 3.** Move the cursor so that the pencil mark is over the RG K line.
- STEP 4.** Construct the elevation gage line by drawing a line through the pencil mark parallel to the RG K line.
- STEP 5.** Place the constructed range gage line over range 10,500, and verify that elevation 512 is read under the elevation gage line in time-setting group 52.
- STEP 6.** Enter the GFT deflection correction on the upper right-hand corner of the cursor.

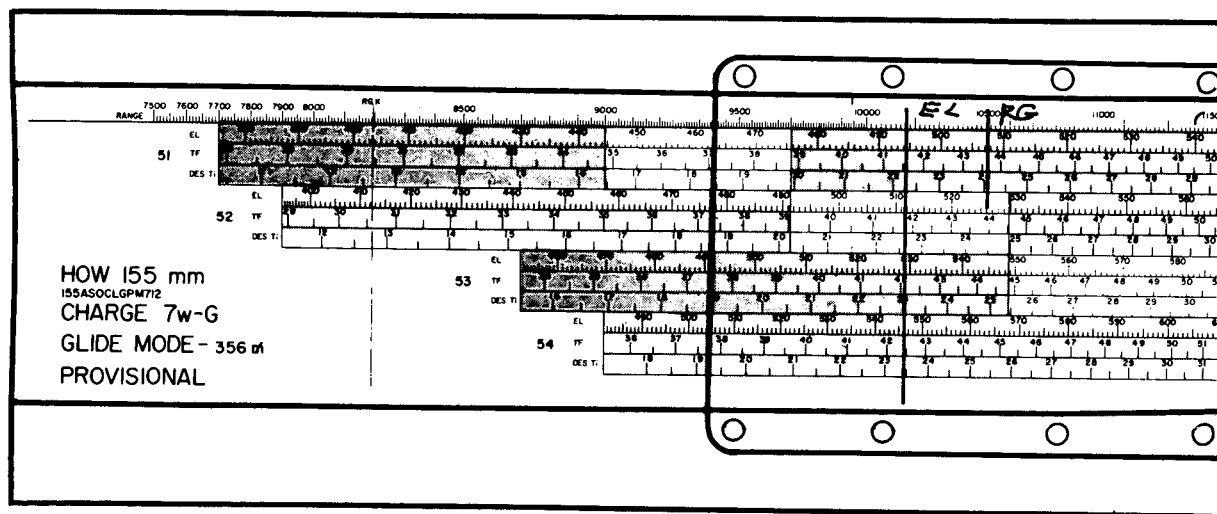


Figure 9-53. M712 glide mode GFT with GFT setting applied.

9-57. SWITCH SETTING

The Copperhead switch setting consists of five numbers (fig 9-54). The first two numbers are the time setting determined by the fire direction center. The last three numbers are the PRF code of the G/VLLD operator. This combination setting establishes a common laser frequency between the round and the G/VLLD.

9-58. COMPUTATION OF SITE

a. The VCO computes site for Copperhead by use of the Copperhead GST (fig 9-55). Three separate range scale slides have been produced to accommodate all modes and charges.

b. The Copperhead GST and the GST for conventional munitions are used in nearly the same manner. The difference is that the offset chart range is used instead of chart range on both the ballistic and the glide mode GSTs and the appropriate time-setting group must be used on the glide mode GST.

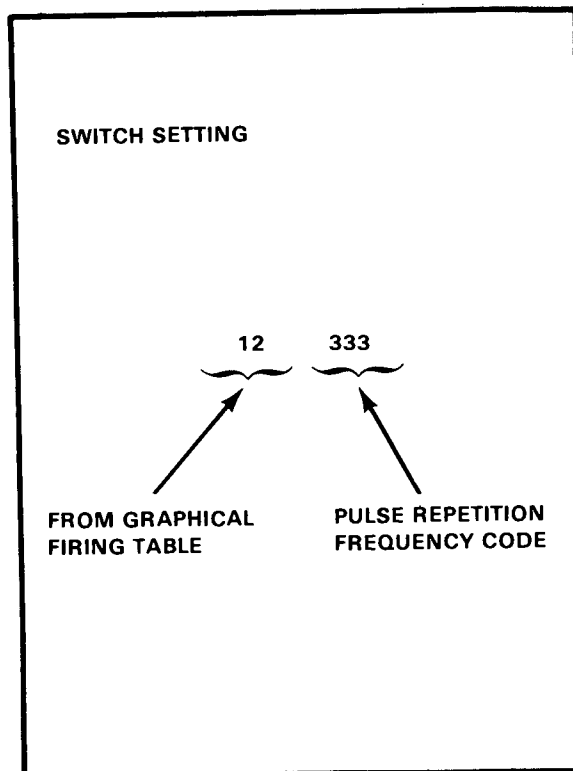


Figure 9-54. Explanation of the switch setting.

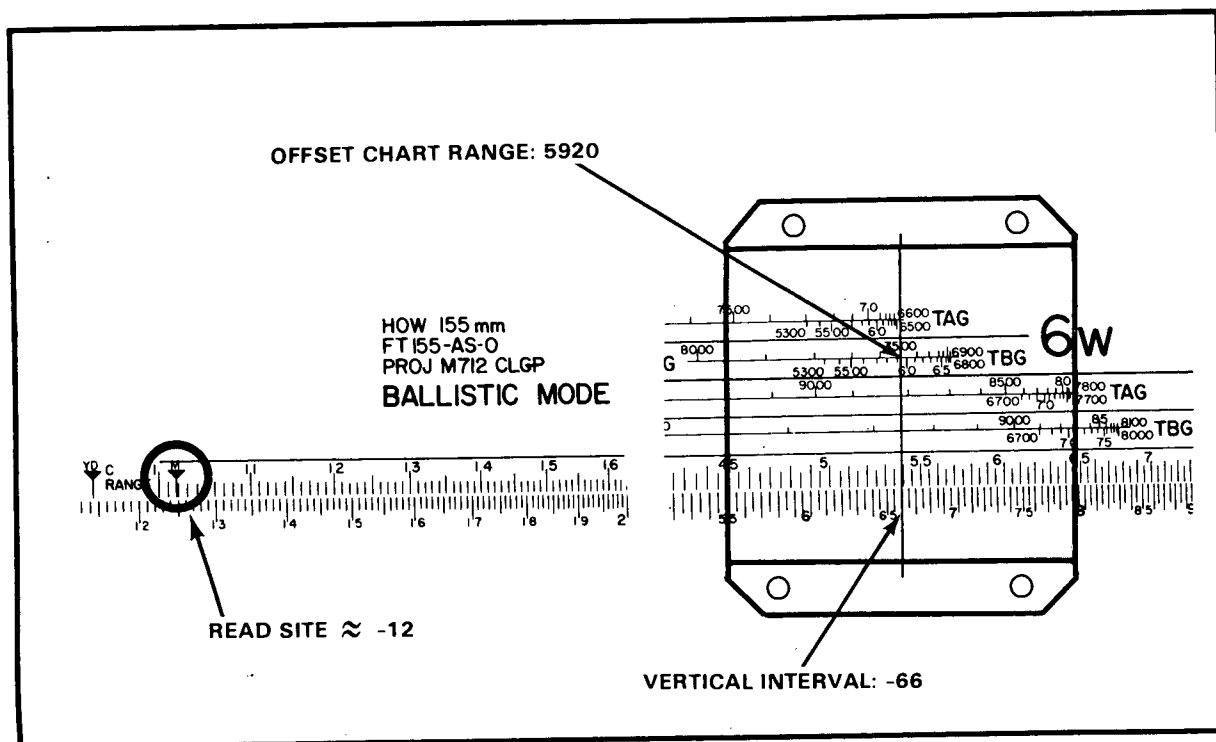


Figure 9-55. Copperhead graphical site table.

9-59. COMPUTATION OF DEFLECTION CORRECTION

There is no drift correction for the Copperhead round. Therefore, the total deflection correction is equal to the GFT deflection correction and is applied throughout that charge and mode without modification.

9-60. COMPUTATION OF FADAC DATA

The FADAC must be programed with Revision 6A before it can compute firing data for Copperhead. Information concerning FADAC Revision 6A will be published separately.

9-61. LIMITS OF THE BATTERY CENTER SOLUTION

a. Manual firing data for Copperhead are initially computed from battery center. If the center of the gun platoon firing the Copperhead mission is located within 100 meters of battery center, the gun platoon can use the firing data computed at battery center. If the platoon center is located farther than 100 meters from battery center, deflection and elevation corrections for the platoon should be computed and applied to the battery center solution. The procedures for computing these corrections are in chapter 13. Corrections are made to the battery center solution burst point.

b. When time for data computation is limited, as is normally the case for targets of opportunity, and the platoon center is located farther than 100 meters from battery center, the FDC should compute at least a deflection correction. Because of the egg shape of a Copperhead footprint, the Copperhead round can compensate for errors in range easier than it can for errors in deflection.

c. When computing data with FADAC, the platoon centers should be stored as battery locations if they are 100 meters or

farther from battery center. Data for the platoons can then be computed by using the mass fire function.

d. The BCS computes separate firing data for each gun. Procedures to modify a battery center solution do not apply to the battery computer system.

9-62. TARGET ATTACK CONTINGENCIES

a. If a target cannot be attacked by Copperhead because of insufficient target cloud height, the FDC must inform the observer. Coordination to fire other types of munitions on the target can then be made between the observer and the FDC.

b. If a target cannot be attacked by Copperhead because of the angle T (greater than 800 mils), the battery FDC should contact the battalion FDC to see if the mission can be taken by another battery having an angle T of 800 mils or less. If another battery is available, the original battery FDC tells the observer to contact the FDC of the battery taking the mission. If no other batteries are available, coordination to fire other types of munitions on the target can be made between the observer and the FDC.

9-63. RECORD OF FIRE

a. Records of fire for Copperhead missions are completed in nearly the same manner as those for conventional fire missions. The offset chart range is entered in the range (Rg) block with the notation "offset chart." The switch setting is entered in the fuze setting (Ti) block with the notation "sw setting." Designate time is written under the time of flight (TF) block.

b. Normally, firing data for planned targets can be computed by use of a Copperhead planned target list work sheet or board. The record of fire can then be used to record the actual firing of the data. Figures 9-56 and 9-57 show how records of fire are completed for various situations. The GFT setting is as follows:

GFT B: Chg 5, LA Bal, Lot RY, Rg 4700, El 356; GFT Df Corr: R3

RECORD OF FIRE																				
Observer T33		CALL FOR FIRE AF/FF/IS/S			Tgt		CHART RG. 5740 RG OFFSET CORR + 500				△ FS									
Grid:		Polar: Dir 1820			Dis 3160		U/D		VA -37		100/R									
Shift		Dir			L/R		+/-		U/D		/R									
2 TANKS, CDH, 3 ROUNDS, BY ROUND AMC											20/R									
FIRE ORDER LFT PLT, BY PIECE, BY RD, AMC CHG 5 OFFSET											HOB Corr									
INITIAL FIRE COMMANDS		FM MF LFT PLT #50 + 60			Rg Chart 5240		Cht Df 3152				Si +6									
Sp Instr BY PIECE, BY RD, AMC		Sh CPH			Lot		Chg 5		Fz		TI 12333		EI 425							
MTO CODE 333		4 T			PER		TF 23				in Eff		Ammo Exp (3) CPH							
SUBSEQUENT FIRE COMMANDS / DES 6 T1																				
Tgt	Location	Priority	Firing Unit	Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si ()	EI	QE	Exp	Type
EM				EM																
2 TANKS DESTROYED OBSR CLOUD ALT 810 CLOUD ALT 1280 EST 8 CAS OBSR ALT +470 TGT ALT -363 CLOUD ALT 1280 TGT CLOUD ALT 925																				
Btry B		DTG 5/22/84 1600		Tgt		Replot Grid		Replot Alt												
DA FORM 4504 1 OCT 78		REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE										FOR USE OF THIS FORM, SEE FM 6-40; THE PROponent AGENCY IS TRADOC								

Figure 9-56. Record of fire—target of opportunity.

RECORD OF FIRE																				
Observer T33		CALL FOR FIRE AF/FF/IS/S FIRE			Tgt AB2235						△ FS									
Grid:		Polar: Dir			Dis		U/D		VA		100/R									
Shift		Dir			L/R		+/-		U/D		/R									
3 TANKS, 4 ROUNDS, AMC											20/R									
FIRE ORDER RT PLT, BY PIECE, BY RD, AMC OFFSET CHT											HOB Corr									
INITIAL FIRE COMMANDS		FM MF RT PLT (2)			Rg		SW SETTING		Cht Df		EI									
Sp Instr BY PIECE, BY RD, AMC		Sh CPH			Lot		Chg 5		Fz		TI 12333		QE 417							
MTO CODE 333		4 T			PER		TF 22				in Eff		Ammo Exp (4) CPH							
SUBSEQUENT FIRE COMMANDS 161																				
Tgt	Location	Priority	Firing Unit	Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si ()	EI	QE	Exp	Type
EM				EM																
3 TANKS DESTROYED EST 12 CAS																				
Btry B		DTG 5/22/84 1600		Tgt		Replot Grid		Replot Alt												
DA FORM 4504 1 OCT 78		REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE										FOR USE OF THIS FORM, SEE FM 6-40; THE PROponent AGENCY IS TRADOC								

Figure 9-57. Record of fire—on-call target.

9-64. FIRE COMMANDS

a. The order in which initial and subsequent fire commands are given is the same as that for conventional fire missions, *except that fuze is omitted and switch setting is sent instead of time.* Figure 9-58 is an example of fire commands.

b. BY PIECE, BY ROUND, AT MY COMMAND is sent to the guns for all Copperhead missions, regardless of the method of control specified by the observer. For each round, the FDC gives the command to fire to the howitzers firing the mission after the observer has given the command **FIRE** (when **AT MY COMMAND** or **BY ROUND**, **AT MY COMMAND** has been specified by the observer).

EXAMPLE:

The observer requested AT MY COMMAND in his call for fire and has given the command to fire. The FDC initiates firing at 20-second intervals.

NUMBER 1 . . . FIRE (wait 20 sec):

NUMBER 2 . . . FIRE (wait 20 sec);

NUMBER 1 . . . FIRE (wait 20 sec);

NUMBER 2... FIRE....

[illegible]

Figure 9-58. Example of fire commands.

*Note. If one howitzer is firing two rounds and the other is firing one round, the howitzer firing two rounds should be fired first to give it maximum time to load its second round. The FDC must closely monitor the howitzer's report of **READY** for each round. If the next gun to fire is not ready, the command to fire should be passed to the one that is ready.*

c. For priority missions, the FDC sends firing data to the guns in a do not load status.

9-65. ENGAGEMENT COMMANDS

a. **Shot.** As soon as the first Copperhead round is fired in a mission, the observer receives **SHOT** from the fire direction center. If he specified **AT MY COMMAND** or omitted the method of control in the call for fire, he receives **SHOT** only once. The subsequent rounds are fired at intervals of at least 20 seconds without notification. The exact interval will be set by unit SOP. If the observer specified **BY ROUND AT MY COMMAND**, he receives **SHOT** for each round fired. If an observer fails to acknowledge **SHOT** for a given round, it is not retransmitted, because the observer's timing would be affected.

b. *Designate (Voice).*

(1) The next and most critical engagement command is **DESIGNATE**. When the observer receives the command **DESIGNATE** from the FDC, he begins designating the target with the G/VLLD. This command is sent at least 20 seconds before impact. If the time of flight is 20 seconds or less, **SHOT** and **DESIGNATE** are sent in the same transmission.

(2) It is mandatory that the observer designate the target during the last 13 seconds of time of flight. After the observer has received **SHOT**, he should begin his own countdown using the time of flight received in the message to observer. If for some reason he has not received a **DESIGNATE** message,

he should begin designation when 13 seconds are left in his countdown.

(3) If the battery is firing the Copperhead rounds automatically at 20-second intervals, the command **DESIGNATE** is sent only for the first round fired. The observer continues designating for the subsequent rounds while moving the laser spot to the next target.

(4) If **SHOT** is given for each round or if the firing interval is greater than 20 seconds, **DESIGNATE** is given for each round

c. **Designate Now (Voice).** If an observer fails to acknowledge the **DESIGNATE** command, the command **DESIGNATE NOW** is sent by the FDC until the observer acknowledges or the time of flight of the round has elapsed. If the observer fails to acknowledge the **DESIGNATE NOW** command, **SHOT** and **DESIGNATE** are sent on the next round fired, regardless of the method of control. Time intervals between transmission of this command may be specified in unit SOP to allow the observer time to acknowledge.

d. **Rounds Complete.** The FDC reports **ROUNDS COMPLETE** after the engagement command for the last round has been sent and acknowledged. If the observer wants to terminate firing before the last round is fired and the FDC is controlling the firing of subsequent rounds, he sends **CHECK FIRING, CANCEL CHECK FIRING, END OF MISSION**. If the observer is controlling the firing of subsequent rounds, he sends **END OF MISSION** to terminate the mission.

e. **Requests for Additional Rounds.** If additional rounds are required to engage the target array, the observer may request them by sending (so many) **ROUNDS, REPEAT, OVER** after the last Copperhead round is fired.

9-66. HIGH-ANGLE FIRE

a. **Introduction.** The tactical situation may dictate engaging targets with Copperhead by firing into or out of deep defilade such as that found in heavily wooded or mountainous areas. When such is the case,

high-angle fire may be requested by the observer or ordered by the FDO on the basis of the terrain in the target area or the battery position.

b. Restrictions. Because of the long times of flight involved, firing Copperhead high angle is not as responsive as firing it in one of the low-angle modes. Because of these restrictions, Copperhead fired in the high-angle mode should be considered only when a target cannot be engaged with Copperhead fired in a low-angle ballistic or glide mode. Restrictions on high-angle fire with Copperhead are as follows:

(1) The minimum range at which high-angle firing data may be controlled is 5,000 meters.

(2) The minimum cloud height required over the target is 2,120 meters.

(3) Charges 4GB and 4WB cannot be used to fire Copperhead high angle.

(4) High-angle fire for Copperhead is accomplished in the ballistic mode only.

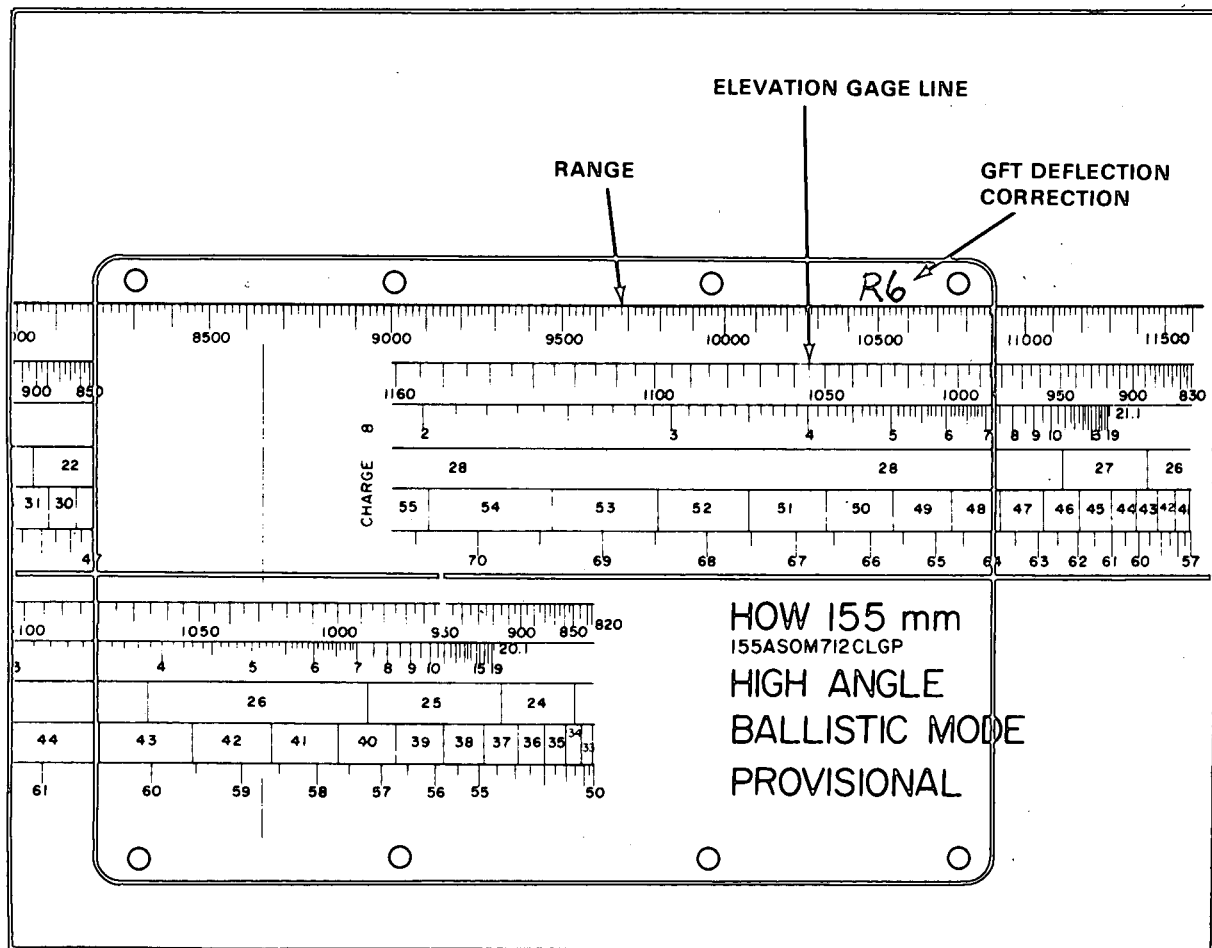
9-67. HIGH-ANGLE GFT

The high-angle GFT for Copperhead (fig 9-59) is similar in design to the high-angle GFT for shell HE (fig 9-60.). The differences are as follows:

a. The Copperhead GFT has time-setting and designate time scales (both increase from right to left).

b. The Copperhead GFT does not have 100/R and drift scales.

c. The Copperhead GFT does not have an MHL on the cursor.



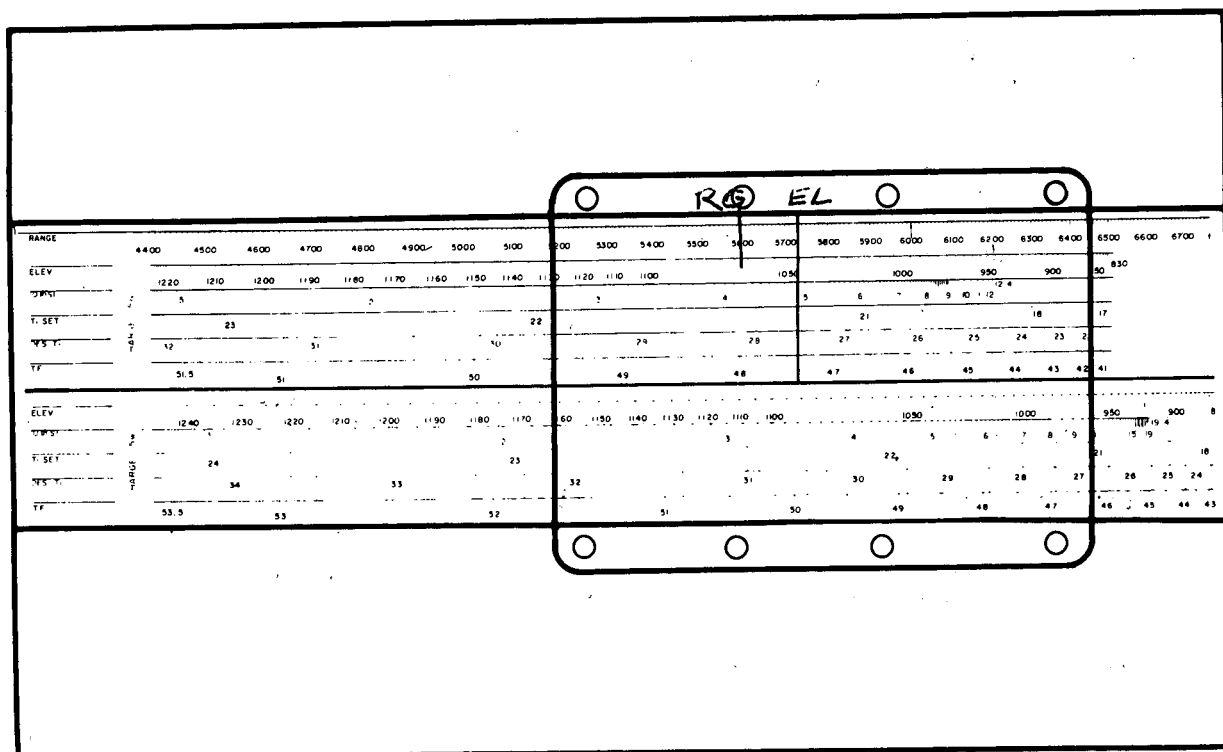


Figure 9-60. High-angle GFT.

9-68. HIGH-ANGLE GFT SETTINGS

a. As in the low-angle modes, a GFT setting should be applied to the high-angle GFT. Since registrations are not fired with Copperhead, high-angle GFT settings are obtained through FADAC or by manually solving a met as described for the Copperhead low-angle ballistic graphical firing table.

b. The ranges for which high-angle GFT settings are computed are in table 9-35.

Note. When a high-angle GFT setting is computed by manually solving a met, the offset chart range listed in table 9-35 for the selected charge is used. If the FADAC/BCS is used to derive a high-angle GFT setting, the corresponding chart range listed in the table for the selected charge is entered into FADAC/BCS. FADAC/BCS automatically applies the range offset correction. In all cases, the GFT setting is applied on the GFT at the offset chart range.

Table 9-35. High-angle GFT setting ranges.

CHARGE	OFFSET CHART RANGE (METERS)	CORRESPONDING CHART RANGE (METERS)
5GB or 5WB	5,200	5,750
6WB	6,770	7,250
7WB	8,360	8,750
8	10,270	10,550

c. The high-angle GFT setting contains the following information:

- (1) Unit.
- (2) Charge.
- (3) Trajectory (for example, high angle).
- (4) Ammunition lot.
- (5) Range (offset chart range).
- (6) Adjusted elevation.
- (7) GFT deflection correction.

EXAMPLE:

GFT B: Chg 5, High Angle, Lot RY, Rg 5200, El 1107; GFT Df Corr: L2.

d. The high-angle GFT setting is applied on the GFT by first drawing a range gage line perpendicular to the range scale through the GFT setting range. This gage line need not extend beyond the range scale. An elevation gage line is then drawn parallel to the range gage line extending through the adjusted elevation on the elevation scale. The GFT deflection correction is placed on the upper right-hand corner of the cursor. Except for the range, all data pertaining to the GFT setting charge should be read from the elevation gage line.

EXAMPLE:

Given: Offset chart range 5980 and GFT setting in example above.

<i>Elevation</i>	<i>960</i>
<i>10-mil site</i>	<i>-10.7</i>
<i>Time setting</i>	<i>21</i>
<i>Designate time</i>	<i>25</i>
<i>Time of flight</i>	<i>45</i>

e. A Copperhead high-angle GFT setting is valid for the range interval of the selected charge when derived at the ranges specified in the example above. It is also valid only for the charge and propellant type for which it was computed and only within the deflection transfer limits established for conventional munitions.

9-69. DATA COMPUTATION

a. Before issuing a high-angle fire order for Copperhead, the FDO must ensure that the minimum range and target cloud height requirements are met.

b. The data for firing Copperhead in the high-angle mode are the same as those for firing Copperhead in the low-angle mode.

c. The charge to fire is determined by selecting the preferred charge based on the chart range to the target. As a general rule, the lowest charge possible is selected. Specific guidelines for charge selection are outlined in table 9-36.

Table 9-36. High-angle charge selection.

RANGE (METERS)	PREFERRED CHARGE
5,000 to 6,500	5GB
6,500 to 8,000	6WB
8,000 to 9,500	7WB
9,500 to 11,600	8

d. After the charge has been selected, enter the high-angle range offset table (fig 9-61) with chart range (expressed to the nearest 100 meters), and extract the range offset correction. Algebraically apply the range offset correction to the chart range. The result is the offset chart range. The offset chart range is the range set off on the GFT to determine firing data.

e. There are no drift corrections for Copperhead high-angle fire. Therefore, the total deflection correction is equal to the GFT deflection correction.

Note. The high-angle range offset correction table (fig 9-61) lists ranges in 200-meter increments. If the chart range is exactly between the listed ranges, apply the offset correction corresponding to the next lower listed chart range.

RANGE OFFSET
BALLISTIC MODE - ANGLE*
RANGE OFFSET IN METERS

TARGET RANGE (METERS)	HEIGHT OF CLOUD CEILING (METERS)	
	MIN	MAX
5000	-600	-600
5200	-590	-590
5400	-580	-580
5600	-560	-560
5800	-550	-550
6000	-540	-540
6200	-530	-530
6400	-520	-520
6600	-510	-510
6800	-500	-500
7000	-490	-490
7200	-480	-480
7400	-470	-470
7600	-450	-450
7800	-440	-440
8000	-430	-430
8200	-420	-420
8400	-410	-410
8600	-400	-400
8800	-390	-390
9000	-380	-380
9200	-370	-370
9400	-360	-360
9600	-340	-340
9800	-330	-330
10000	-320	-320
10200	-310	-310
10400	-300	-300
10600	-280	-280
10800	-270	-270
11000	-260	-260
11200	-250	-250
11400	-240	-240
11600	-230	-230

*USE ONLY FOR CLOUD CEILINGS ABOVE 2120 METERS OR
ABOVE THE MAXIMUM ORDINATE IF THE MAXIMUM ORDINATE
IS BELOW 2120 METERS

Figure 9-61. Range offset, ballistic mode (high angle).

f. Site for high-angle Copperhead missions is ignored unless the angle of site, computed by use of the offset chart range, is greater than ± 30 mils. Site is computed in the same manner as in conventional high-angle missions.

9-70. EXAMPLE OF A HIGH-ANGLE MISSION

a. The FDO of Battery A has just received a Copperhead call for fire on three tanks in a ravine. The following Copperhead high-angle GFT setting was derived by FADAC for charge 5GB:

GFT B: Chg 5, High Angle, Lot RY, Rg 5200, El 1107; GFT Df Corr: L2

b. The following information was provided by the observer:

Observer cloud height greater than 2,120 meters
Observer altitude 435
Observer-target direction 1730
Observer-target distance 3370
Vertical angle -11

c. After quickly ensuring that minimum range and target cloud height requirements are met, the FDO issues his fire order: RIGHT PLATOON, HIGH ANGLE, BY PIECE, BY ROUND, AT MY COMMAND. The following chart information is obtained:

Chart range 5750
Chart deflection 3079
Angle T 450 right

RECORD OF FIRE																			
CALL FOR FIRE										CHT RG 5750					△ FS				
Observer T 68 AF/FFE/IS/S Tgt										RG OFFSET CORR - 550					100/R				
Grid:										OFFSET CHT RG 5200					/R				
Polar: Dir 1730 Dis 3370 U/D VA -11										20/R					HOB Corr				
Shift 3 TANKS IN RAVINE, CPH 4 ROUNDS, 1/2 Round AMC										2 Si + 31					10m Si - 3.2				
FIRE ORDER RT PLT, BY PIECE, BY ROUND, AMC, CHGS, INCLUDE SITE										Df Corr L2					Si - 10				
INITIAL FIRE COMMANDS / FM MF RT PLT ②										RG OFFSET CHART 5200					Chf Df 3079				
Sp Instr HA, BY PIECE, BY ROUND, AMC Sh CPH Lot										Chg 5 Fz					Df 3081				
MTO CODE 333										21 (45DR)					PER				
Tgt Location Priority Firing Unit										SUBSEQUENT FIRE COMMANDS DEST 29					in Eff				
Dir, MF Sh, Fz Dev Rg HOB Corr MF, Sh, Chg, Fz FS Corr Ti Chart Df Df Corr () Df Fired Chart Rg HOB Corr () El QE Exp Type																			
3 TANKS DESTROYED OBS CLOUDHD 2120 CLOUD ALT > 2555 EST 12 CAS OBS ALT + 435 TGT ALT - 399 CLOUD ALT > 2555 > 2156																			
Dtry B DTG 5/22/84 Tgt Replot Grid Replot Alt																			
DA FORM 4504 REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE FOR USE OF THIS FORM, SEE FM 6-40; THE PROPOHENT AGENCY IS TRADOC																			

Figure 9-62. Record of fire—Copperhead high-angle mission.

d. Noting that the chart range falls between 5000 and 6500, the computer selects charge 5GB.

e. With the chart range expressed to the nearest 200 meters (5,800 meters), the computer enters the range offset table and extracts the range offset correction of -550.

f. The computer now computes the offset chart range by adding the range offset correction to the chart range: Offset chart range (5200) = chart range (5750) + range offset correction (-550).

g. The initial firing data are obtained from the Copperhead high-angle GFT by setting off the offset chart range under the range gage line.

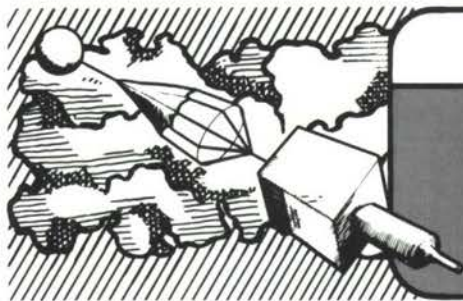
Elevation	1107
10-mil site	-3.2
Time setting	22
Designate time	29
Time of flight	49

h. The computer requests and obtains an angle of site (+31) from the VCO.

i. Since the angle of site is greater than ± 30 mils, the FDO amends his fire order by announcing **INCLUDE SITE**, and site is computed by the following method:

Site (-10) = 10-mil site factor (-3.2) $\times$ angle of site $\div 10$ (3.1).

j. The completed record of fire for this mission is shown in figure 9-62.



CHAPTER 10

METEOROLOGICAL CORRECTIONS AND VELOCITY ERROR

The state of the atmosphere through which a projectile passes is one of the elements that affects a projectile after it leaves the tube. The three elements of the atmosphere that the artillery considers in its gunnery computations are wind (direction and speed), air temperature, and air density. The met message contains ballistic information about these atmospheric conditions.

Section I

PURPOSE AND USE OF MET MESSAGES

10-1. NONSTANDARD CONDITIONS

a. To place accurate fires on targets of known location without adjustment, corrections must be applied to firing table data to compensate for the effects of nonstandard conditions of weather, materiel, and position. The most accurate way to determine these corrections is to conduct a registration. Normally, a registration to determine current corrections is prohibited or not feasible. In such a case, closely approximated corrections can be determined by measuring deviations from standard conditions and computing corrections for these deviations. The techniques used to measure deviations from standard and to compute corrections for them are called met corrections.

b. The firing tables used to produce firing data for artillery cannons are based on an arbitrary set of standard conditions for weather, materiel, and position. To gain a better understanding of the gunnery problem and artillery meteorological procedures, you must know the standard conditions on which the firing tables and TACFIRE/BCS or FADAC calculations are based. (Standard conditions are identified in figure 10-1).

c. Variations from these standards create nonstandard conditions that must be corrected for by either registration or computation. The manual computations performed in the FDC to compensate for nonstandard conditions are done on DA Form 4200. There are two met techniques used—the concurrent met and the subsequent met.

STANDARD WEATHER	THE AIR TEMPERATURE IS 59° F. THE AIR DENSITY IS 1225 g/m ³ AT SEA LEVEL. THERE IS NO WIND.
STANDARD POSITION	THE GUN AND TARGET ARE AT THE SAME ALTITUDE. THE RANGE IS ACCURATE. THERE IS NO ROTATION OF THE EARTH.
STANDARD MATERIEL	THE GUN REACTS TO FIRING THE SAME WAY EVERY TIME. ALL SETTINGS ARE PERFECT. THE PROJECTILE AND FUZE ARE MANUFACTURED PERFECTLY. THE PROPELLANT TEMPERATURE IS 70° F. THE MUZZLE VELOCITY IS STANDARD. THE TRUNNIONS ARE LEVEL.

Figure 10-1. Standard conditions.

10-2. CONCURRENT MET

a. A concurrent met is solved to separate the total corrections determined by a registration into two parts. These parts are *met corrections*, which are made to the elements that can be easily measured and corrected, and *position corrections*, which are made to the elements that cannot be measured. The total corrections for range, fuze setting, and deflection are caused by the total variations from standard conditions of weather, materiel, and position existing at the time of registration. Weather information is provided to artillery units by artillery met sections in the format of a met message. For the concurrent met technique to be used successfully, it is important that the registration be fired very close to the same time that the met section is measuring the actual weather conditions.

b. If a registration is fired at the same time the met section is measuring the existing weather conditions, it is possible to determine the total corrections needed to compensate for

nonstandard weather conditions. When the registration is fired, the following variable, nonstandard conditions can be determined:

- (1) The effects of wind, air temperature, and air density.
- (2) The projectile weight and propellant temperature of the lot fired.
- (3) The difference in altitude between the gun and the target.
- (4) The drift at the registration point range.
- (5) The effects of the earth's rotation on both range and deflection.

c. The nonstandard conditions that cannot be measured are called *position corrections* and are usually small, difficult to measure, and relatively constant. When all the variable nonstandard conditions have been measured and the corrections computed, it is then possible to subtract the met (variable) corrections from the total corrections and determine the amount of position (constant) nonstandard conditions.

met corrections +
(variable)

position corrections
(constant)

total corrections =

d. The concurrent met technique starts with total range, total fuze, and total deflection correction from a registration. The corrections due to met are subtracted to isolate position corrections that are considered constant.

total corrections -

met corrections =

position corrections

10-3. SUBSEQUENT MET

a. After a registration has been conducted, the concurrent met has been solved, and position constants have been isolated, it will be unnecessary to register again from the same position. Met messages received after the concurrent met are called subsequent mets. New total corrections and

thus new GFT settings can be determined by use of the subsequent met technique.

b. When a subsequent registration is not possible, the subsequent met technique is used to produce a current GFT setting. A subsequent met is solved by using DA Form 4200. Other applications of the subsequent met technique are eight-direction met, met to a target, and met to a met check gage point.

new met corrections +

(new variables)

old position corrections =
(constant)

new total corrections

10-4. VELOCITY ERROR

a. Ballistic variations from firing table standards that cannot be measured include moisture content of the propellant, shell surface finish, and survey or target-location

errors. Corrections for all unknown variations are included in the total corrections determined for registration. Unknown variations affecting range are totaled and are called position velocity errors. Position velocity error variations include factors affecting developed muzzle velocity; factors affecting the ballistics of the projectile; mechanical limitations; and errors in survey, charts, FDC equipment, and fire control instruments.

b. Position velocity errors are assumed to be the measurement of weapon and system performance. They are not considered subject to change as are weather and other measurable nonstandard conditions. Velocity error is muzzle velocity variation plus position velocity error expressed as meters per second. The computed position velocity error should be treated as a constant. The position VE can be used to determine a GFT setting when registration is impractical. The process of determining the GFT setting without registering is called met + VE.

Section II.

MET MESSAGES

10-5. CHARACTERISTICS

Current meteorological conditions must be measured to correct for nonstandard conditions caused by weather. This measurement is done by the artillery met section. One of the section's jobs is to sample the weather at various altitudes. These sample weather data are converted, manually or by computer, to give specific weather information at specific altitudes. These weather data are transmitted to the artillery units in a fixed format called a met message. There are five types of met messages used by the field artillery—ballistic (B), computer (CM), fallout (F), sound ranging (SR), and target acquisition (TA). The fallout message is used in nuclear and chemical fallout predictions and will not be discussed here. The sound ranging met message is used by sound ranging platoons in determining the locations of sound sources.

The target acquisition met message is used by radar platoons of the target acquisition battery.

10-6. BALLISTIC MET MESSAGE

a. The ballistic met message is a coded message containing information about current atmospheric conditions. The two types of ballistic met messages provided for artillery fire are type 2 messages, which are used in air defense artillery, and type 3 messages, which are used by field artillery cannon units and field artillery rocket units for firing at surface targets. Type 3 messages are used to solve the met data correction sheet. The introductory portion of the firing tables for each weapon specifies which type of met message is to be used for that weapon.

INTRODUCTION	
METB31 (GROUP 1)	345982 (GROUP 2)
270950 (GROUP 3)	037991 (GROUP 4)
BODY	
002107	029957
012208	029954
022309	033953
032410	037954
042610	039953
052812	042951

Figure 10-2. Ballistic met message.

Type 3 messages are used for all elevations for all charges for all howitzers in manual/hand-held calculator FDC operations.

b. The ballistic met message is divided into an introduction and a body (fig 10-2).

(1) The introduction of the ballistic met message consists of four six-character groups.

(a) *Group 1.* The first three letters (MET) in group 1 identify the transmission as a met message. The next letter (B) indicates that it is a ballistic met message. The first digit (3) indicates the type of met message. The last digit (1) designates the octant of the earth in which the met station is located. In this case, 1 indicates that the met station is between 90°W and 180°W longitude and that it is north of the equator (north latitude) (fig 10-3). Figure 10-3 also contains the key to the octant codes.

(b) *Group 2.* Group 2 designates the center of the area in which the met message is valid. This is expressed in tens, units, and tenths of degrees of latitude and longitude (345 = 34.5° = 30°30' north latitude and 982 = 98.2° = 98.12' west longitude) or, when the number 9 is used to designate the octant, the six digits or letters represent the coded location of the met station that produced the message.

(c) *Group 3.* The first two digits (27) in group 3 represent the day of the month the met message is valid. The next three digits

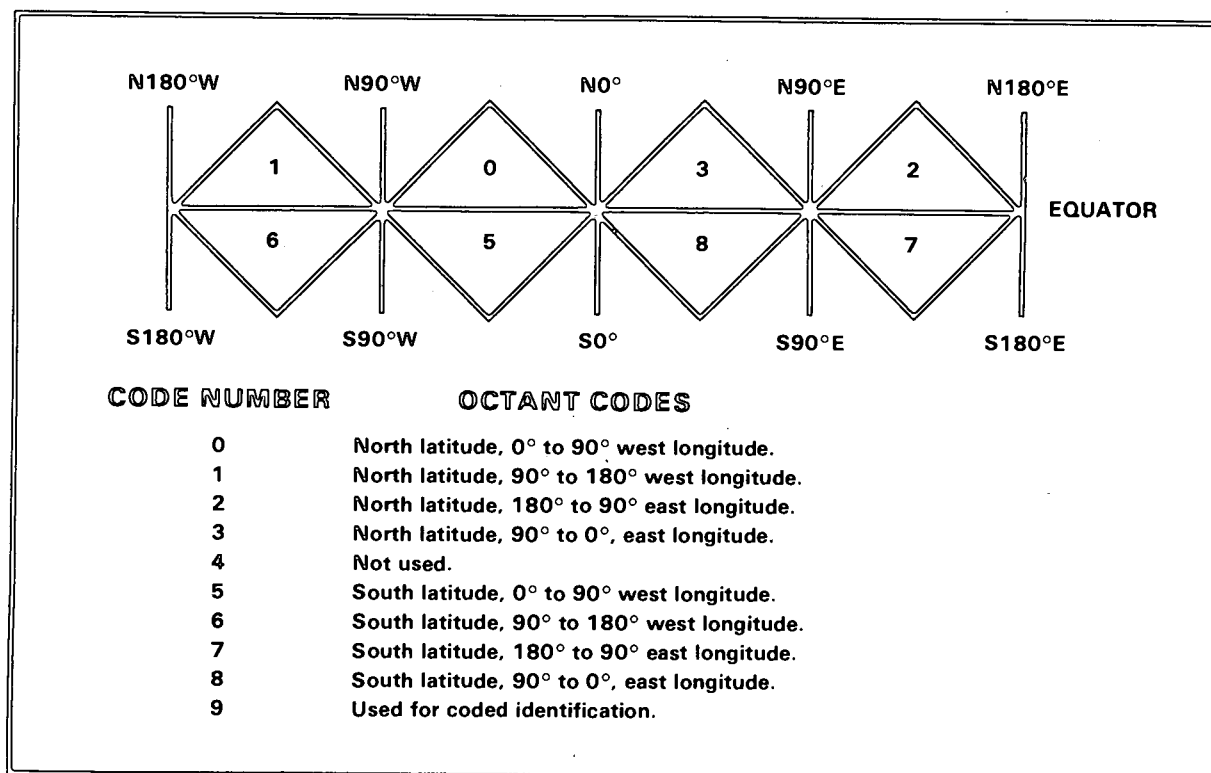


Figure 10-3. Met station octant locations.

(095) indicate the hour in tens, units, and tenths of hours (095 = 09.5 hours = 0930) the met message becomes valid. The hours refer to Greenwich mean time. The last digit (0) in group 3 indicates the number of hours the message will remain valid. The United States does not attempt to predict the length of time a met message will remain valid. Instead, during combat, the United States normally obtains new met data every 2 hours. Therefore, the last digit in group 3 of a ballistic met message produced by the United States will always be 0. Some allied nations predict the length of time a met message will remain valid. These predictions vary from 1 to 8 hours. Code figure 9 indicates 12 hours.

(d) *Group 4.* The first three digits (037) of group 4 indicate the altitude of the met station (meteorological datum plane [MDP]) above mean sea level in multiples of 10 meters (037 = 370 meters). The next three digits (991) indicate the atmospheric pressure at the MDP expressed as a percentage (to the nearest 0.1 percent) of the International Civil Aviation Organization (ICAO) standard atmospheric pressure at mean sea level (991 = 99.1 percent). When a value is equal to or greater than 100 percent, the initial digit 1 is omitted.

(2) The body of the met message can consist of 16 met message lines (00 through 15). Each line consists of two six-number groups. Each line contains the ballistic data for a particular altitude zone. Ballistic data are the weighted average of the conditions that exist from the surface up through the altitude zone indicated by the line number and back to the surface (fig 10-4).

(a) The first two digits of the first group on the line identify the altitude zone (00 [surface] through 15 [18,000 meters]). Line 03 is used as an example.

(b) The next two digits (24) of the first group indicate from which direction the ballistic wind is blowing expressed in hundreds of mils true azimuth (24 = 2,400 mils).

(c) The last two digits (10) of the first group indicate the speed of the ballistic wind in knots (10 = 10 knots).

ZONE HEIGHT (METERS)	LINE NUMBER ZZ	DIRECT (100's dd)
SURFACE	00	
200	01	
500	02	
1000	03	
1500	04	
2000	05	
3000	06	
4000	07	
5000	08	
6000	09	
8000	10	
10000	11	
12000	12	
14000	13	
16000	14	
18000	15	

Figure 10-4. Zone height.

(d) The first three digits (037) of the second group on the line indicate the ballistic air temperature expressed as a percentage (to the nearest 0.1 percent) of the ICAO standard temperature (037 = 103.7 percent). When a value is equal to or greater than 100 percent for temperature or pressure, the initial digit 1 is omitted.

(e) The last three digits (954) of the second group indicate the ballistic air density expressed as a percentage (to the nearest 0.1 percent) of the ICAO standard density (954 = 95.4 percent).

c. The message is recorded on DA Form 3675 (Ballistic Met Message) (fig 10-5).

10-7. COMPUTER MET MESSAGE

The computer met message, like the ballistic met message, is a coded message that reports the atmospheric conditions in selected layers starting at the surface and extending to an altitude that will normally include the maximum ordinate of field artillery weapons that use these data. Unlike the ballistic met message used in the manual computations (where the weather conditions existing in one layer or zone are weighted against the conditions in lower layers and reported as percentages of the standard), the computer met reports actual average wind speed, air temperature, and pressure in each layer. The computer met message is used by FADAC and the BCS and TACFIRE computers in the computation of the equations of motion used in the computer's

BALLISTIC MET MESSAGE								
For use of this form, see FM 6-15; the proponent agency is United States Continental Army Command.								
TYPE MSG	OCTANT	LOCATION L ₀ L ₀ L ₀ or XXX		DATE YY	TIME (GMT) G ₀ G ₀ G ₀	DURATION (HOURS) G	STATION HEIGHT (10's M) hhh	MOP PRESSURE % OF STD PPP
3	1	345	982	27	095	0	037	991
LINE NUMBER ZZ		BALLISTIC WINDS		BALLISTIC AIR				
		DIRECTION (100's MILS) dd	SPEED (KNOTS) FF	TEMPERATURE (% OF STD) TTT	DENSITY (% OF STD) AAA			
00		21	07	029		957		
01		22	08	029		954		
02		23	09	033		954		
03		24	10	037		954		
04		26	10	039		953		

Figure 10-5. Ballistic met message.

program. The computer met message is divided into an introduction and a body and is recorded on DA Form 3677 (Computer Met Message) (fig 10-6).

a. The introduction of the computer met message consists of four six-character groups.

(1) **Group 1.** The first five letters (METCM) identify the transmission as a computer met message. The last figure (digit 1) is the designation of the octant of the earth in which the station is located. The octant code key is the same as the key for the ballistic met message.

(2) **Group 2.** Group 2 in the computer met message is the same as group 2 in the ballistic met message.

(3) **Group 3.** Group 3 in the computer met message is the same as group 3 in the ballistic met message.

(4) **Group 4.** The first three digits (049) of group 4 indicate the altitude of the met station MDP above mean sea level in tens of meters (490). The last three digits (987) indicate the atmospheric pressure, in

millibars, at the met station. When the value is greater than 99.9, the first digit 1 is omitted (for example, 009 = 100.9).

b. The body of the met message consists of 27 met message lines (00 through 26). Each line consists of two eight-number groups. Each line contains the actual average weather data for a particular altitude zone.

(1) The first two digits of the first group indicate the met line number that identifies the zone. The lines are numbered in sequence from 00 (surface conditions) through 26. Line 00 is used as an example.

(2) The next three digits (260) indicate the direction from which the wind is blowing expressed in tens of mils (2,600) true azimuth.

(3) The last three digits (018) indicate the wind speed expressed in knots (18 knots).

(4) The first four digits of the second group indicate the actual air temperature expressed in degrees Kelvin to the nearest tenth of a degree (269.8° Kelvin).

(5) The last four digits of the second group indicate the actual air pressure, in

COMPUTER MET MESSAGE							
For use of this form, see FM 6-15; the proponent agency is United States Continental Army Command.							
OCTANT	LOCATION		DATE	TIME (GMT)	DURATION (HOURS)	STATION HEIGHT (10's M)	MDP PRESSURE
Q	L _a L _a L _a or xxx	L _o L _o L _o or xxx	YY	G _o G _o G _o	G	hhh	MB's. P _d P _d P _d
1	512	018	07	095	0	049	987
ZONE VALUES							
LINE NUMBER	WIND DIRECTION (10's M)		WIND SPEED (KNOTS)		TEMPERATURE (1/10°K)		PRESSURE (MILLIBARS)
ZZ	ddd		FFF		TTTT		PPPP
00	260		018		2698		0987
01	260		018		2689		0974
02	270		022		2674		0955
03	300		025		2660		0900
04	310		030		2651		0848

Figure 10-6. Computer met message.

millibars, (0987) to the nearest millibar (987 millibars).

10-8. MET MESSAGE ERRORS

When the met message is received by the FDC, it should be checked to ensure that it is correct. The validity of the met message should be questioned if any of the following errors exist:

a. Ballistic Met Errors. Ballistic met errors are as follows (fig 10-7):

(1) Drastic changes (over 1,000 mils) or sudden reverses of wind direction from line to line. Ballistic winds should flow in a fairly uniform manner.

(2) Severe increases or decreases (10 to 15 knots) in wind speed from line to line.

(3) Temperature and density changing in the same direction. As temperature increases, density should decrease.

(4) Drastic changes (2 percent or more) in density or temperature. Ballistic temperature and density should change smoothly between zones.

(5) Consecutive messages that do not show a trend. Consecutive messages should show a trend that relates to the actual weather conditions unless the weather conditions have changed during sunrise or sunset transition periods or because of a frontal passage, rain, snow, or a rapid increase or decrease in cloud cover.

BALLISTIC MET MESSAGE								
For use of this form, see FM 6-15; the proponent agency is United States Continental Army Command.								
TYPE MSG	OCTANT	LOCATION		DATE	TIME (GMT)	DURATION (HOURS)	STATION HEIGHT (10's M)	MDP PRESSURE (% OF STD)
K	Q	L ₀ L ₀ L ₀ or xxx	L ₀ L ₀ L ₀ or xxx	YY	G ₀ G ₀ G ₀	G	hhh	PPP
3	1	625	468	29	025	0	025	001
LINE NUMBER ZZ		BALLISTIC WINDS		BALLISTIC AIR				
		DIRECTION (100's MILS) dd	SPEED (KNOTS) FF	TEMPERATURE (% OF STD) TTT		DENSITY (% OF STD) ΔΔΔ		
00		31	04	052		902		
01		25	13	048		907		
02		30	12	040		914		
03		64	12	019		920		
04		34	13	032		922		
05		36	31	024		911		
06								
07								
		OVER 1000	OVER 15 KNOTS	OVER 2%		BOTH DECREASING		

Figure 10-7. Ballistic met message errors.

b. Computer Met Errors. Computer met errors are as follows (fig 10-8):

- (1) Drastic wind direction changes (over 1,000 mils) or sudden reverses in wind direction from line to line.
- (2) Abrupt increases or decreases (10 to 15 knots) in wind speeds from line to line.
- (3) Severe increase or decrease (over 20° Kelvin) in temperature from line to line.
- (4) Differences in identification line pressure and surface pressure.
- (5) Increases in pressure. Pressure should decrease smoothly from line to line. Pressure will never increase with height.

10-9. MET MESSAGE SPACE AND TIME VALIDITY

a. Space Considerations. The accuracy of a met message may decrease as the distance from the meteorological sounding site increases. Local topography has a pronounced effect on the distance that met data can be reasonably extended. In mountainous terrain, distinct wind variations occur over short distances. This effect extends to much greater heights than the mountain tops. Large bodies of water will affect both time and space considerations of the met message because of the land and sea breezes and the effect of humidity on density. Increases in humidity cause decreases in air density. It would be impossible to compute an

COMPUTER MET MESSAGE							
For use of this form, see FM 6-15; the proponent agency is United States Continental Army Command.							
OCTANT	LOCATION L _a L _a L _a or xxx L _o L _o L _o or xxx		DATE YY	TIME (GMT) G ₀ G ₀ G ₀	DURATION (HOURS) G	STATION HEIGHT (10's M) hhh	MDP PRESSURE MB's P _d P _d P _d
Q							
1	344	982	17	175	0	036	966
ZONE VALUES							
LINE NUMBER	WIND DIRECTION (10's M) ddd		WIND SPEED (KNOTS) FFF		TEMPERATURE (1/10°K) TTTT		PRESSURE (MILLIBARS) PPPP
ZZ							
00	310	004	3030		0966		
01	249	013	3012		0953		
02	316	012	2966		0928		
03	503	013	3199		0886		
04	371	101	2882		0888		
05	455	015	2762				
06							
07							
08							
09							
10							

OVER 1000m / 101 KNOTS, OBVIOUS ERROR / DRASTIC CHANGE / PRESSURE INCREASE

Figure 10-8. Computer met message errors.

exact distance for every combination of weather and terrain that might exist. Over gently rolling terrain, met messages for artillery are considered valid up to 20 kilometers from the balloon release point (met section). The validity distance decreases proportionately with the roughness of the terrain and the proximity of large bodies of water.

b. Time Considerations. The passage of time may decrease the accuracy of a message because of the changing nature of weather. With the present equipment, it is extremely difficult for the artillery met section to provide met messages more frequently than every 2 hours over an extended period of time. There are no specific rules for determining the usable time. That determination will depend on the characteristics of the atmosphere, periods of transition, met section movement, personnel, supplies, equipment, and the altitude of the met message (line number) required by the artillery firing units. When the weather pattern is variable, the usable time is variable. If a frontal passage is forecast for the area, the met section will take a new sounding after the front passes. When the

weather pattern is stable and is forecast to remain so, time between messages may be extended up to several hours depending on the time of day and existing weather conditions.

c. Use of Met Data. Results of many studies based on artillery firing and met data show that the order of preference of various sources of met data is as follows:

(1) A current met message that is less than 2 hours old (unless an exchange of air mass has occurred since the met message was produced or unless periods of transition are involved) and is from a station within 20 kilometers of the midpoint of the trajectory (upwind is best). A 4-hour-old met message may be used except when day/night transitions or frontal passages are occurring.

(2) A current met message from the nearest station up to 80 kilometers from the midpoint of the trajectory (upwind is best) and less than 2 hours old.

(3) Met messages over 2 hours old but from a station within 20 kilometers of the midpoint of the trajectory.

Section III

CONCURRENT MET

10-10. CHARACTERISTICS

A concurrent met is solved to determine position constants. Met corrections are determined and then subtracted from the total corrections to yield position constants. The recommended sequence for solving a concurrent met is to follow the sequence of the tables in the tabular firing table. This recommended sequence is outlined below.

10-11. SEQUENCE FOR SOLUTION OF A CONCURRENT MET

a. Determine and enter the total corrections from the GFT setting.

b. Enter the known data.

c. Determine the met line number from table A of the tabular firing table.

d. Enter the met message data.

e. Compute Δh , height of target above gun, and chart direction of the wind.

f. Enter the TFT and determine the following:

(1) Complementary range from table B.

(2) Wind components from table C.

(3) Corrections to temperature and density from table D.

(4) Correction to muzzle velocity for propellant temperature from table E.

g. Compute corrected values for temperature, density, entry range, crosswind, range wind, and variations from standard.

h. Enter the TFT and determine the following:

(1) Unit corrections from table F.

(2) Rotation corrections for range from table H.

(3) Rotation corrections for azimuth from table I.

i. Compute the met deflection correction and position deflection correction.

j. Compute the met range correction and position velocity error.

k. Enter variations from standard in the MET FUZE CORRECTION block of DA Form 4200, and determine unit corrections from table J.

l. Compute the met fuze correction and position fuze correction.

10-12. SOLUTION OF A CONCURRENT MET

The sample problem below describes the solution of a concurrent met by use of the steps outlined in paragraph 10-11. The following known data are given:

From the registration on Registration Point 2:

GFT A: Chg 4, Lot XY, Rg 5140, El 335, Ti 18.9

Adjusted deflection 2757

Chart deflection 2755

Adjusted QE 340

Direction of fire 0395

Lot Y is M3A1 (GB) propellant

From the executive officer:

Projectile weight 3 squares

Propellant temperature +82° F

From a map or firing chart:

Altitude of registration point 376

Altitude of battery 355

Latitude 30°N

From the met station:

METB31 347985 271250 055972
 005816 010954
 015816 010956
 025917 008958
 036021 004960
 046023 002962

From the MV record registering gun:

MVV Chg 4GB, Lot XY = -7.7 meters per second

a. Enter the total corrections from section I of DA Form 4757 (Registration/Special Corrections Work Sheet) (app J) (fig 10-9) on the met data correction sheet (fig 10-10).

b. Enter the known data (fig 10-10). Entered data consist of the following:

- (1) Charge.
- (2) Adjusted quadrant elevation.

REGISTRATION/SPECIAL CORRECTION WORK SHEET									
For use of this form, see FM 6-40, proponent agency is TRADOC									
SECTION I. REGISTRATION COMPUTATION									
ACHIEVED RANGE					DEFLECTION CORRECTION				
1	CHART RANGE	<u>5310</u> (10 METERS)			7	CORRECTED DEFLECTION (REGISTRATION)	<u>2759</u> (1 MIL)		
2	REGISTERING PIECE DISPLACEMENT (F - B)	<u>-220</u> (10 METERS)			8	REGISTERING PIECE DISPLACEMENT CORRECTION (6) (L · R)	<u>-2</u> (1 MIL)		
3	ACHIEVED RANGE (1 + 2)	<u>5140</u> (10 METERS)			9	ADJUSTED DEFLECTION (7 + 8)	<u>2757</u> (1 MIL)		
REGISTERING PIECE DISPLACEMENT CORRECTION					10	CHART DEFLECTION	<u>2755</u> (1 MIL)		
4	LATERAL DISPLACEMENT (L · R)	<u>R10</u> (5 METERS)			11	TOTAL DEFLECTION CORRECTION (9 + 10) (L · R)	<u>L2</u> (1 MIL)		
5	ACHIEVED RANGE (3)	<u>5140</u> (10 METERS)			12	DRIFT CORRECTION (~ ADJUSTED ELEVATION) (L)	<u>L7</u> (1 MIL)		
6	REGISTERING PIECE DISPLACEMENT CORRECTION (4 + 5) (L · R)	<u>-2</u> (1 MIL)			13	GRAPHICAL FIRING TABLE (GFT) DEFLECTION CORRECTION (11 + 12)	<u>R5</u> (1 MIL)		
GFT SETTING (MANUAL METHOD)									
14	GFT <u>A</u>	CHARGE <u>4</u>	LOT <u>XY</u>	RANGE <u>5140</u>	ELEVATION <u>335</u>	TIME <u>18.9</u>	DEFLECTION CORRECTION		
15	GFT	CHARGE	LOT	RANGE	ELEVATION	TIME	TOTAL		
16	GFT	CHARGE	LOT	RANGE	ELEVATION	TIME	GFT		
							<u>L2</u> <u>R5</u>		
GFT SETTING (COMPUTER METHOD)									
17	BCS AMMUNITION AND FIRE UNIT REGISTRATION	RANGE	RANGE CORRECTION		TIME CORRECTION		DEFLECTION CORRECTION		
18	HAND-HELD CALCULATOR RESIDUALS	DEFLECTION CORRECTION		FUZE K		RANGE K			
19	FADAC RESIDUALS	DEFLECTION ±		FUZE ±		RANGE K ±			
REMARKS									
<u>5140 + 2405380</u> <u>335</u> <u>18.9 - 1.1</u>									

DA FORM 4757 SEP 84

EDITION OF OCTOBER 1978 IS OBSOLETE

Figure 10-9. Total corrections.

MET DATA CORRECTION SHEET									
For use of this form, see FM 6-40; proponent agency is TRADOC.									
BATTERY DATA					MET MESSAGE				
CHARGE	ADJ GE	CHART RG	LATITUDE	TYPE MESSAGE	OCTANT	AREA/UNIT			
408	340	5140	30°N						
ALT OF STRY (1000)				DATE	TIME	ALT MDP	PRESSURE		
(335) 360									
ALT OF MDP				LINE NO.	WIND DIR	WIND SPEED	AIR TEMP	AIR DENSITY	
STRY ABOVE MDP (AM)				A & B CORRECTION					
ALT OF TARGET (nearest meter)				CORRECTED VALUES					
376									
HEIGHT OF BURST ABOVE TARGET									
ALT OF BURST									
376									
ALT OF STRY (nearest meter)									
355									
HEIGHT OF TARGET (Name) ABOVE GUN (NO)				COMP RG	CHART RG	ENTRY RG			
					5140				
WIND COMPONENTS AND DEFLECTION									
WHEN DIRECTION OF WIND IS LESS THAN GUN FIVE ADD				0400					
DIRECTION OF WIND				TOTAL DFC CORR L2					
				MET DFC CORR					
				POS DFC CORR					
DIRECTION (0395) 0400				ROTATION L CORR R					
CHART DIRECTION OF WIND				DRIFT CORR L					
				CROSS WIND CORR R					
CROSS WIND SPEED * COMP R				KNOTS * UNIT CORR					
RANGE WIND SPEED * COMP H				TAIL HEAD KNOTS					
				NET DEFL L CORR R					
MET RANGE CORRECTION									
	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS			
RANGE WIND	T	0	T						
	H		H						
AIR TEMP		100%	0						
			1						
AIR DENSITY		100%	0						
			1						
PROJ WEIGHT	30	40	0						
			1						
ROTATION									
NET RANGE CORR									
COMPUTATION OF VE									
PROP TEMP	VE	M/S			TOTAL RANGE CORRECTION	+240			
+82	CHANGE TO MV FOR PROP TEMP	M/S			MET RANGE CORRECTION				
	AV	M/S	MV UNIT CORRECTION		AV RANGE CORRECTION				
					TOTAL RANGE CORRECTION				
OLD VE * NEW VE * 2 * AVG VE					M/S				
MET FUZE CORRECTION									
	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS					
AV	0					5300			
	1					+240			
RANGE WIND	T					5140 335 18.9			
	H					-1.0			
AIR TEMP	0					19.9			
	1								
AIR DENSITY	0					TOTAL FUZE CORRECTION			
	1					-1.0			
PROJ WEIGHT	0					MET FUZE CORRECTION			
	1					FUZE CORRECTION			
						TOTAL FUZE CORRECTION			
MET FUZE CORR									
OLD FZ CORR * NEW FZ CORR * 2 * AVG FZ CORR					M/S				
TARGET NO	REF PT 2		BATTERY	A		DATE/TIME			
						5/22/84			

DA FORM 4200

REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE

Figure 10-10. Known data and total corrections.

- (3) Chart range.
- (4) Latitude (nearest 10°).
- (5) Battery altitude (nearest meter and nearest 10 meters).
- (6) Target altitude (nearest meter).
- (7) Direction of fire (nearest mil and nearest 100 mils).
- (8) Projectile weight.
- (9) Propellant temperature.
- (10) Lazy Z.
- (11) Total range.
- (12) Total fuze correction.
- (13) Total deflection correction (plus basic formula for determining position deflection correction).
- (14) Target number.
- (15) Date-time group.

c. Enter Table A for the appropriate charge with the adjusted QE, and extract the met line number (fig 10-11). The met line number indicates the whole line of met through which the maximum ordinate of the trajectory passes.

FT 155-AM-2

PROJ, HE, M107
FUZE, PD, M557

TABLE A
LINE NUMBER

CHARGE
4G

LINE NUMBERS OF METEOROLOGICAL MESSAGE

QUADRANT ELEVATION MILS	LINE NUMBER
0.0- 146.3	0
146.4- 280.2	1
280.3- 421.8	2
421.9- 561.9	3
562.0- 686.1	4
686.2- 863.6	5
863.7-1119.8	6
1119.9-1300.0	7

NOTE - WHEN THE PROJECTILE MUST HIT THE TARGET ON THE ASCENDING BRANCH OF ITS TRAJECTORY, USE HEIGHT OF TARGET IN METERS TO ENTER THE TABLE ON PAGE XXIV TO DETERMINE LINE NUMBER.

Figure 10-11. Line numbers of met messages.

BATTERY DATA				MET MESSAGE			
CHARGE 4GB	ADJ QE 340	CHART RG 5140	LATITUDE 30°N	TYPE MESSAGE MET B 3	OCTANT 1	AREA/UNIT 347985	
ALT OF BTRY (10 ³) (345)		360	DATE 27	TIME 1230	ALT MDP 550	PRESSURE 97.2	
ALT OF MDP		550	LINE NO. 02	WIND DIR 5900	WIND SPEED 17	AIR TEMP 100.8	AIR DENSITY 95.8
BTRY ABOVE MDP (AN) BELOW			A & B CORRECTION			+	-
ALT OF TARGET (nearest meter)		376	CORRECTED VALUES				
HEIGHT OF BURST ABOVE TARGET		—					
ALT OF BURST		376					
ALT OF BTRY (nearest meter)		355					
HEIGHT OF TARGET (nearest meter) ABOVE GUN (M)							
			COMP RG	CHART RG 5140	ENTRY RG		

Figure 10-12. Entering the met data.

d. Enter the met message data (fig 10-12). Record the data from the identification line and the line determined in c above in the MET MESSAGE block. Record the MDP altitude, wind direction, and wind speed values in the other blocks as indicated.

e. Compute Δh , height of target above gun, and chart direction of wind (fig 10-13).

(1) Determine the difference in altitude between the battery and the MDP to correct the values for temperature and density.

BATTERY DATA				MET MESSAGE			
CHARGE 4GB	ADJ QE 340	CHART RG 5140	LATITUDE 30°N	TYPE MESSAGE MET B 3	OCTANT 1	AREA/UNIT 347985	
ALT OF BTRY (10 ³) (345)		360	DATE 27	TIME 1230	ALT MDP 550	PRESSURE 97.2	
ALT OF MDP		550	LINE NO. 02	WIND DIR 5900	WIND SPEED 17	AIR TEMP 100.8	AIR DENSITY 95.8
BTRY ABOVE MDP (AN) BELOW		190	A & B CORRECTION			+	-
ALT OF TARGET (nearest meter)		376	CORRECTED VALUES				
HEIGHT OF BURST ABOVE TARGET		—					
ALT OF BURST		376					
ALT OF BTRY (nearest meter)		355					
HEIGHT OF TARGET (nearest meter) ABOVE GUN (M)		+ 21 $\approx$ 0					
			COMP RG	CHART RG 5140	ENTRY RG		
WIND COMPONENTS AND DEFLECTION							
WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE AOD		6400					
DIRECTION OF WIND		5900					
DIRECTION OF (0395)		0400					
CHART DIRECTION OF WIND		5500					
		ROTATION L CORR R DRIFT					

Figure 10-13. Computation of Δh , height of target above gun, and chart direction of wind.

(2) Determine height of target above gun (vertical interval) to the nearest 100 meters. It will be used to determine complementary range.

(3) Use the chart direction of the wind to divide the wind direction into crosswind and range wind components. Subtract

direction of fire from direction of wind to determine chart direction of wind.

f. Enter table B (fig 10-14) with the chart range to the nearest listed value and the height of target above gun to the nearest 100, and extract the complementary range. Record as shown in figure 10-18.

CHARGE 4G		TABLE B								FT 155-AM 2 FT 155-AM 2					
COMPLEMENTARY RANGE LINE NUMBER										PROJ. HE. M107 PROJ. HE. M107 FUZE. PD. M557 FUZE. PD. M557					
CHANGE IN RANGE, IN METERS, TO CORRECT FOR COMPLEMENTARY ANGLE OF SITE															
LINE NUMBERS OF METEOROLOGICAL MESSAGE															
LINE NO	RANGE METERS	HEIGHT OF TARGET ABOVE GUN - METERS								HEIGHT OF TARGET ABOVE GUN					
		400	300	200	100	0	100	200	300	400	500	600	700	800	
0	3500	-59	-46	-31	-16	0	17	34	52	71	91	112	133	156	
	3600	-61	-47	-32	-16	0	17	35	54	73	94	115	137	161	
	3700	-64	-49	-33	-17	0	18	36	56	76	97	119	142	166	
	3800	-66	-50	-34	-18	0	18	38	57	78	100	123	146	171	
	3900	-68	-52	-35	-18	0	19	39	59	81	103	126	151	176	
1	4000	-70	-54	-37	-19	0	20	40	61	83	106	130	155	187	
	4100	-72	-55	-38	-19	0	20	41	63	86	110	134	160	191	
	4200	-75	-57	-39	-20	0	21	42	65	88	113	138	165	196	
	4300	-77	-59	-40	-21	0	21	44	67	91	116	142	170	201	
	4400	-79	-61	-41	-21	0	22	45	69	94	120	147	175	206	
	4500	-82	-63	-43	-22	0	23	46	71	96	123	151	180	211	
	4600	-84	-65	-44	-22	0	23	48	73	99	127	155	185	216	
	4700	-87	-66	-45	-23	0	24	49	75	102	130	160	190	221	
	4800	-89	-68	-47	-24	0	25	50	77	105	134	164	196	226	
	4900	-92	-70	-48	-24	0	25	52	79	108	138	169	202	231	
2	5000	-95	-72	-49	-25	0	26	53	82	111	142	174	207	242	
	5100	-97	-74	-51	-26	0	27	55	84	114	146	179	213	247	
	5200	-100	-76	-52	-26	0	28	56	86	117	150	184	219	252	
	5300	-103	-79	-53	-27	0	28	58	89	121	154	189	226	257	
	5400	-105	-81	-55	-28	0	29	59	91	124	159	195	232	262	
	5500	-108	-83	-56	-29	0	30	61	94	128	163	200	239	267	
	5600	-111	-85	-58	-30	0	31	63	96	131	168	206	246	272	
	5700	-114	-87	-59	-30	0	32	65	99	135	173	212	253	277	
	5800	-117	-90	-61	-31	0	32	66	102	139	178	218	261	282	
	5900	-121	-92	-63	-32	0	33	68	105	143	183	225	269	287	
3	6000	-124	-95	-64	-33	0	34	70	108	147	188	232	277	292	
	6100	-127	-97	-66	-34	0	35	72	111	151	194	239	286	297	
	6200	-131	-100	-68	-35	0	36	74	114	156	200	246	295	302	
	6300	-134	-103	-70	-36	0	37	77	118	161	206	254	305	307	
	6400	-138	-106	-72	-37	0	39	79	121	166	213	262	315	312	
	6500	-142	-109	-74	-38	0	40	81	125	171	220	271	325	317	
	6600	-146	-112	-76	-39	0	41	84	129	177	227	280	337	322	
	6700	-150	-115	-78	-40	0	42	86	133	182	235	290	349	327	
	6800	-154	-118	-81	-41	0	43	89	137	189	243	300	362	332	
	6900	-159	-122	-83	-43	0	45	92	142	195	252	312	377	337	
4	7000	-164	-126	-86	-44	0	46	95	147	202	261	324	393	342	

Figure 10-14. Table B.

g. Enter table C (fig 10-15) corresponding to the chart direction of the wind, and extract the range wind and crosswind. Record as shown in figure 10-18.

CHARGE
4G

TABLE C
WIND COMPONENTS

FT 155 AM 2
PROJ. HE, M107
FUZE, PD, M557

COMPONENTS OF A ONE KNOT WIND

CHART DIRECTION OF WIND	CROSS WIND	RANGE WIND	CHART DIRECTION OF WIND	CROSS WIND	RANGE WIND
MIL	KNOT	KNOT	MIL	KNOT	KNOT
0	0	H1.00	3200	0	T1.00
100	R.10	H.99	3300	L.10	T.99
200	R.20	H.98	3400	L.20	T.98
300	R.29	H.96	3500	L.29	T.96
400	R.38	H.92	3600	L.38	T.92
500	R.47	H.88	3700	L.47	T.88
600	R.56	H.83	3800	L.56	T.83
700	R.63	H.77	3900	L.63	T.77
800	R.71	H.71	4000	L.71	T.71
900	R.77	H.63	4100	L.77	T.63
1000	R.83	H.56	4200	L.83	T.56
1100	R.88	H.47	4300	L.88	T.47
1200	R.92	H.38	4400	L.92	T.38
1300	R.96	H.29	4500	L.96	T.29
1400	R.98	H.20	4600	L.98	T.20
1500	R.99	H.10	4700	L.99	T.10
1600	R1.00	0	4800	L1.00	0
1700	R.99	T.10	4900	L.99	H.10
1800	R.98	T.20	5000	L.98	H.20
1900	R.96	T.29	5100	L.96	H.29
2000	R.92	T.38	5200	L.92	H.38
2100	R.88	T.47	5300	L.88	H.47
2200	R.83	T.56	5400	L.83	H.56
2300	R.77	T.63	5500	L.77	H.63
2400	R.71	T.71	5600	L.71	H.71
2500	R.63	T.77	5700	L.63	H.77
2600	R.56	T.83	5800	L.56	H.83
2700	R.47	T.88	5900	L.47	H.88
2800	R.38	T.92	6000	L.38	H.92
2900	R.29	T.96	6100	L.29	H.96
3000	R.20	T.98	6200	L.20	H.98
3100	R.10	T.99	6300	L.10	H.99
3200	0	T1.00	6400	0	H1.00

NOTE - FOR A COMPLETE EXPLANATION OF THE USE OF THIS TABLE, SEE PARAGRAPH 13, EXPLANATION OF COMPONENTS OF A ONE KNOT WIND.

Figure 10-15. Table C.

FT 155-AM-2

TABLE D

CHARGE
4G

PROJ. KE. M107
FUZE. PD. M557

TEMPERATURE
AND DENSITY CORRECTIONS

CORRECTIONS TO TEMPERATURE (DT) AND DENSITY (DD), IN PERCENT,
TO COMPENSATE FOR THE DIFFERENCE IN ALTITUDE,
IN METERS, BETWEEN THE BATTERY AND THE MDP

ΔH		0	+10-	+20-	+30-	+40-	+50-	+60-	+70-	+80-	+90
0	DT	0.0	0.0	0.0	-0.1+	-0.1+	-0.1+	-0.1+	-0.2+	-0.2+	-0.2+
	DD	0.0	-0.1+	-0.2+	-0.3+	-0.4+	-0.5+	-0.6+	-0.7+	-0.8+	-0.9+
+100-	DT	-0.2+	-0.2+	-0.2+	-0.3+	-0.3+	-0.3+	-0.3+	-0.4+	-0.4+	-0.4+
	DD	-1.0+	-1.1+	-1.2+	-1.3+	-1.4+	-1.5+	-1.6+	-1.7+	-1.8+	-1.9+
+200-	DT	-0.5+	-0.5+	-0.5+	-0.6+	-0.6+	-0.6+	-0.6+	-0.7+	-0.7+	-0.7+
	DD	-2.0+	-2.1+	-2.2+	-2.3+	-2.4+	-2.5+	-2.6+	-2.7+	-2.8+	-2.9+
+300-	DT	-0.7+	-0.7+	-0.7+	-0.8+	-0.8+	-0.8+	-0.8+	-0.9+	-0.9+	-0.9+
	DD	-3.0+	-3.1+	-3.2+	-3.3+	-3.4+	-3.5+	-3.6+	-3.7+	-3.8+	-3.9+

NOTES - 1. ΔH IS BATTERY HEIGHT ABOVE OR BELOW THE MDP.
2. IF ABOVE THE MDP, USE THE SIGN BEFORE THE NUMBER.
3. IF BELOW THE MDP, USE THE SIGN AFTER THE NUMBER.

Figure 10-16. Table D.

h. Enter table D (fig 10-16) with Δh , and extract the corrections that must be applied to temperature and density to compensate for the difference in altitude between the battery and the MDP. Record as shown in figure 10-18.

i. Enter table E (fig 10-17) with the propellant temperature to the nearest degree Fahrenheit, and interpolate the change to muzzle velocity. Record the value as shown in figure 10-18. Interpolation is not necessary if

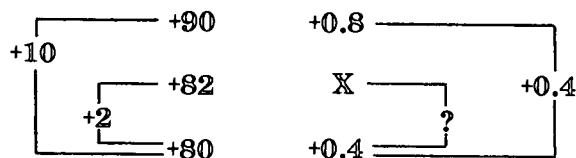
all values have been interpolated previously and if a locally produced supplemental table E has been constructed listing MV changes for all temperatures. Standard propellant temperature is $+70^\circ \text{F}$. An increase in propellant temperature increases muzzle velocity. A decrease in propellant temperature decreases muzzle velocity. Table E lists the effects of propellant temperature on muzzle velocity. Using the sample problem, interpolate the change to MV for propellant temperature as follows:

TABLE E		
PROPELLANT TEMPERATURE		
EFFECTS ON MUZZLE VELOCITY DUE TO PROPELLANT TEMPERATURE		
TEMPERATURE OF PROPELLANT DEGREES F	EFFECT ON VELOCITY M/S	TEMPERATURE OF PROPELLANT DEGREES C
-40	-6.4	-40.0
-30	-5.6	-34.4
-20	-4.8	-28.9
-10	-4.2	-23.3
0	-3.5	-17.8
10	-2.9	-12.2
20	-2.4	-6.7
30	-1.8	-1.1
40	-1.3	4.4
50	-0.9	10.0
60	-0.4	15.6
70	0.0	21.1
80	0.4	26.7
90	0.8	32.2
100	1.2	37.8
110	1.7	43.3
120	2.1	48.9
130	2.5	54.4

Figure 10-17. Table E.

TEMPERATURE
OF
PROPELLANT
(° F)

EFFECT
ON
VELOCITY
(M/S)



$$\frac{2}{10} = \frac{X}{0.4}$$

$$2(0.4) = 10X$$

$$.8 = 10X$$

$$.08 = X = 1$$

$$\begin{array}{rcl} +0.4 & +80^\circ \text{F} \\ +0.1 & +2^\circ \text{F} (80^\circ - 90^\circ) \\ \hline +0.5 \text{ m/s} & +82^\circ \text{F} \end{array}$$

Therefore,
A correction of $+0.5 \text{ m/s}$ corresponds to a propellant temperature of $+82^\circ \text{F}$.

MET DATA CORRECTION SHEET									
For use of this form, see FM 6-40; proponent agency is TRADOC.									
BATTERY DATA					MET MESSAGE				
CHARGE	ADJ QE	CHART RG	LATITUDE	TYPE MESSAGE	OCTANT	AREA/UNIT			
46B	340	5140	30°N	MET B 3	1	347985			
ALT OF BTRY (10')		360		DATE	TIME	ALT MDP	PRESSURE		
(355)				27	1230	550	97.2		
ALT OF MDP		550		LINE NO.	WIND DIR	WIND SPEED	AIR TEMP	AIR DENSITY	
				02	5900	17	100.8	95.8	
BTRY ABOVE MDP (AN)		190		A & B CORRECTION					
ELONG									
ALT OF TARGET (nearest meter)		376		CORRECTED VALUES					
HEIGHT OF BURST ABOVE TARGET		—							
ALT OF BURST		376							
ALT OF BTRY (nearest meter)		355							
HEIGHT OF TARGET (Target) ABOVE GUN (M)		+21 ≈ 0		COMP RG	CHART RG	ENTRY RG			
				+0	5140				
WIND COMPONENTS AND DEFLECTION									
WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD		8400		TOTAL DEF CORR L 2 — MET DEF CORR POS DEF CORR					
DIRECTION OF WIND		5900							
DIRECTION (0395)		0400							
CHART DIRECTION OF WIND		5500							
CROSS WIND	WIND SPEED	17 * COMP		77	KNOTS		UNIT CORR		CROSS WIND
RANGE WIND	WIND SPEED	17 * COMP		63	KNOTS		UNIT CORR		RANGE WIND
MET RANGE CORRECTION									
RANGE WIND	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS			
	T	0	T						
AIR TEMP		100%	D						
AIR DENSITY		100%	D						
PROJ WEIGHT	30	40	O						
ROTATION			I						
PROPellant TEMPERATURE CORRECTIONS									
PROP TEMP	VE	M/S		TOTAL RANGE CORRECTION		+240			
+82 °F	CHANGE TO MV FOR PROP TEMP	+0.5		MET RANGE CORRECTION					
	ΔV	M/S		ΔV RANGE CORRECTION					
				TOTAL RANGE CORRECTION					

Figure 10-18. Complimentary range, range wind, crosswind, temperature and density corrections, and propellant temperature.

j. Compute the corrected values for temperature and density by applying the values extracted from table D to the met message temperature and density.

k. Compute the range by adding the complementary range from table B to the

chart range. Express the result to the nearest 100 meters.

l. Compute the crosswind and range wind by multiplying the wind speed from the met message by the crosswind and the range wind components extracted from table C. Express the values to the nearest knot.

MET DATA CORRECTION SHEET									
For use of this form, see FM 6-40; proponent agency is TRADOC.									
BATTERY DATA					MET MESSAGE				
CHARGE	ADJ DE	CHART RG	LATITUDE	TYPE MESSAGE	OCTANT	AREA/UNIT			
4GB	340	5140	30°N	MET B 3	1	347 985			
ALT OF DTRY (1000)		360	DATE	TIME	ALT MDP	PRESSURE			
(355)			27	1230	550	97.2			
ALT OF MDP		550	LINE NO.	WIND DIR	WIND SPEED	AIR TEMP		AIR DENSITY	
			02	5900	17	100.8		95.8	
DTRY ABOVE GULCH (1000)		190	Δ B CORRECTION			0.4		0.9	
ALT OF TARGET (nearest meter)		376	CORRECTED VALUES			101.2		97.7	
HEIGHT OF OURST ABOVE TARGET									
ALT OF OURST		376							
ALT OF DTRY (nearest meter)		355							
HEIGHT OF TARGET (nearest) ABOVE GUN (1000)		121 = 0	COMP RG	CHART RG	ENTRY RG	5100			
			+0	5140	5140				
WIND COMPONENTS AND DEFLECTION									
WIND DIRECTION OF WIND IS LESS THAN DIR FIRE ADD		6000	TOTAL OF CORR L 2						
DIRECTION OF WIND		5900	- MET DE CORR						
			POS DE CORR						
DIRECTION (0395)		0400							
CHART DIRECTION OF WIND		5500							
CROSS WIND	WIND SPEED	17	COSS	77	13	KNOTS	UNIT CORR	CROSS WIND	
RANGE WIND	WIND SPEED	17	COSS	63	11	KNOTS	UNIT CORR	RANGE WIND	
MET RANGE CORRECTION									
	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS			
RANGE WIND	11	0	11						
AIR TEMP	101.2	100%	1.2						
AIR DENSITY	97.7	100%	2.3						
PROJ HEIGHT	376	400	10						
ROTATION									
MET RANGE CORR									
COMPUTATION OF VE									
PROP TEMP	VE	M/S	TOTAL RANGE CORRECTION		7240				
+82	CHANGE TO MV FOR PROP TEMP	0.5	MET RANGE CORRECTION						
	ΔV	M/S	ΔV RANGE CORRECTION						
			TOTAL RANGE CORRECTION						
OLD VE: _____ NEW VE: _____ 2: AVG VE: _____ M/S									

Figure 10-19. Determination of corrected values and variations from standard.

m. Compute variations from standard by entering the values for range wind, air temperature, air density, and projectile weight in the MET RANGE CORRECTION block and compare to the standard values listed (fig 10-19).

n. Enter table F (fig 10-20) with the entry range. Columns 8 through 19 list unit corrections for drift, crosswind, muzzle velocity, range wind, air density, air temperature, and projectile weight. Extract azimuth corrections for drift and crosswind

CHARGE 4G		FT 155-AM-2 PROJ. HE, M107 FUZE, PD, M557				TABLE F CORRECTION FACTORS										CHARGE 4G	
1	2	3	8	9	10	11	12	13	14	15	16	17	18	19			
R A N G E	E L E V	FS FOR GRAZE BURST FUZE M564	AZIMUTH CORRECTIONS		RANGE CORRECTIONS FOR												
			DRIFT (CORR TO L)	CW OF 1 KNOT	MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KNOT		AIR TEMP 1 PCT		AIR DENSITY 1 PCT		PROJ WT OF 1 SQ (4 SQ STD)				
					DEC	INC	HEAD	TAIL	DEC	INC	DEC	INC	DEC	INC			
M	MIL		MIL	MIL	M	M	M	M	M	M	M	M	M	M			
0	0.0		0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0			
100	5.1		0.0	0.01	0.6	-0.6	0.0	0.0	0.0	0.0	0.0	0.0	-1	1			
200	10.1		0.0	0.01	1.3	-1.2	0.0	0.0	0.1	-0.1	0.0	0.0	-2	2			
300	15.2		0.1	0.01	1.9	-1.7	0.1	0.0	0.2	-0.1	0.0	0.0	-3	3			
400	20.3		0.1	0.02	2.5	-2.2	0.1	-0.1	0.3	-0.2	-0.1	0.1	-4	4			
500	25.4		0.2	0.02	3.1	-2.7	0.2	-0.1	0.5	-0.2	-0.1	0.1	-5	5			
600	30.6	1.9	0.3	0.03	3.6	-3.2	0.3	-0.1	0.6	-0.3	-0.1	0.1	-6	6			
700	35.8	2.2	0.4	0.03	4.2	-3.7	0.4	-0.2	0.9	-0.4	-0.2	0.2	-7	7			
800	41.1	2.5	0.5	0.04	4.7	-4.1	0.5	-0.2	1.1	-0.5	-0.2	0.2	-7	8			
900	46.4	2.8	0.6	0.04	5.3	-4.5	0.6	-0.2	1.4	-0.6	-0.3	0.3	-8	8			
1000	51.7	3.2	0.7	0.04	5.8	-5.0	0.7	-0.3	1.7	-0.8	-0.3	0.3	-9	9			
1100	57.1	3.5	0.8	0.05	6.3	-5.4	0.8	-0.3	2.0	-0.9	-0.4	0.4	-10	10			
1200	62.5	3.8	0.8	0.05	6.8	-5.8	0.9	-0.4	2.3	-1.0	-0.4	0.4	-10	11			
1300	67.9	4.2	0.9	0.05	7.3	-6.2	1.1	-0.4	2.6	-1.1	-0.5	0.5	-11	11			
1400	73.4	4.5	1.0	0.06	7.9	-6.6	1.2	-0.5	2.9	-1.3	-0.6	0.6	-12	12			
1500	78.9	4.9	1.1	0.06	8.4	-7.0	1.4	-0.5	3.3	-1.4	-0.7	0.6	-13	13			
1600	84.4	5.2	1.2	0.07	8.8	-7.3	1.5	-0.6	3.6	-1.6	-0.7	0.7	-13	14			
1700	90.0	5.5	1.3	0.07	9.3	-7.7	1.7	-0.6	4.0	-1.7	-0.8	0.8	-14	14			
1800	95.6	5.8	1.4	0.07	9.8	-8.1	1.8	-0.7	4.4	-1.8	-0.9	0.9	-14	15			
1900	101.3	6.2	1.6	0.08	10.3	-8.4	2.0	-0.8	4.7	-2.0	-1.0	1.0	-15	16			
2000	107.0	6.6	1.7	0.08	10.8	-8.8	2.2	-0.8	5.1	-2.1	-1.1	1.1	-16	16			
2100	112.8	6.9	1.8	0.08	11.3	-9.2	2.3	-0.9	5.5	-2.3	-1.2	1.2	-16	17			
2200	118.6	7.3	1.9	0.09	11.7	-9.5	2.5	-1.0	5.8	-2.4	-1.3	1.3	-17	17			
2300	124.4	7.6	2.0	0.09	12.2	-9.9	2.7	-1.0	6.2	-2.6	-1.4	1.4	-17	18			
2400	130.3	8.0	2.1	0.09	12.7	-10.2	2.8	-1.1	6.6	-2.7	-1.5	1.5	-18	19			
2500	136.2	8.3	2.2	0.10	13.1	-10.6	3.0	-1.2	6.9	-2.9	-1.7	1.6	-19	19			
2600	142.2	8.7	2.3	0.10	13.6	-10.9	3.2	-1.3	7.3	-3.0	-1.8	1.8	-19	20			
2700	148.2	9.1	2.5	0.10	14.1	-11.3	3.4	-1.3	7.6	-3.2	-1.9	1.9	-20	20			
2800	154.3	9.4	2.6	0.11	14.5	-11.6	3.5	-1.4	8.0	-3.3	-2.0	2.0	-20	21			
2900	160.4	9.8	2.7	0.11	15.0	-12.0	3.7	-1.5	8.4	-3.4	-2.2	2.2	-21	22			
3000	166.6	10.2	2.9	0.12	15.4	-12.3	3.9	-1.6	8.7	-3.6	-2.3	2.3	-21	22			
3100	172.9	10.5	3.0	0.12	15.9	-12.7	4.1	-1.6	9.1	-3.7	-2.5	2.4	-22	23			
3200	179.2	10.9	3.1	0.12	16.3	-13.0	4.2	-1.7	9.4	-3.9	-2.6	2.6	-22	24			
3300	185.5	11.3	3.2	0.13	16.8	-13.4	4.4	-1.8	9.8	-4.0	-2.7	2.7	-23	24			
3400	191.9	11.7	3.4	0.13	17.3	-13.7	4.6	-1.9	10.1	-4.1	-2.9	2.9	-23	25			
3500	198.4	12.0	3.5	0.13	17.7	-14.0	4.8	-1.9	10.4	-4.3	-3.1	3.1	-24	25			

Figure 10-20. Table F.

o. Enter table H (fig 10-22) with the entry range to the nearest listed value and the azimuth of fire to the nearest listed value. If the azimuth is between 0 and 3200, enter the table from the top. If the azimuth is between 3200 and 6400, enter it from the bottom. The table lists corrections that are applied to range to compensate for the earth's rotation.

FT 155-AM-2

TABLE H

CHARGE
4GPROJ. HE, M107
FUZE, PD, M557

ROTATION - RANGE

CORRECTIONS TO RANGE, IN METERS, TO COMPENSATE
FOR THE ROTATION OF THE EARTH

RANGE METERS	AZIMUTH OF TARGET - MILS								
	0 3200	200 3000	400 2800	600 2600	800 2400	1000 2200	1200 2000	1400 1800	1600 1600
500	0	0	-1+	-1+	-2+	-2+	-2+	-2+	-2+
1000	0	-1+	-2+	-2+	-3+	-4+	-4+	-4+	4+
1500	0	-1+	-3+	-4+	-5+	-5+	-6+	-6+	-7+
2000	0	-2+	-3+	-5+	-6+	-7+	-8+	-8+	-9+
2500	0	-2+	-4+	-6+	-7+	-9+	-10+	-10+	-10+
3000	0	-2+	-5+	-7+	-9+	-10+	-11+	-12+	-12+
3500	0	-3+	-5+	-8+	-10+	-12+	-13+	-14+	-14+
4000	0	-3+	-6+	-9+	-11+	-13+	-14+	-15+	-15+
4500	0	-3+	-6+	-9+	-12+	-14+	-16+	-16+	-17+
5000	0	-4+	-7+	-10+	-13+	-15+	-17+	-18+	-18+
5500	0	-4+	-7+	-11+	-14+	-16+	-18+	-19+	-19+
6000	0	-4+	-8+	-11+	-14+	-17+	-18+	-20+	-20+
6500	0	-4+	-8+	-11+	-14+	-17+	-19+	-20+	-20+
7000	0	-4+	-8+	-11+	-15+	-17+	-19+	-20+	-21+
7500	0	-4+	-8+	-11+	-14+	-17+	-18+	-20+	-20+
8000	0	-3+	-7+	-10+	-13+	-15+	-16+	-17+	-18+
.....									
8000	0	-2+	-3+	-5+	-6+	-7+	-8+	-9+	-9+
7500	0	-1+	-1+	-1+	-2+	-2+	-2+	-3+	-3+
7000	0	0	+1-	+1-	+1-	+1-	+2-	+2-	+2-
6500	0	+1-	+2-	+3-	+4-	+5-	+5-	+5-	+5-
6000	0	+2-	+3-	+5-	+6-	+7-	+8-	+9-	+9-
5500	0	+2-	+5-	+7-	+9-	+10-	+11-	+12-	+12-
5000	0	+3-	+6-	+9-	+12-	+14-	+15-	+16-	+16-
4500	0	+4-	+8-	+12-	+15-	+18-	+20-	+21-	+22-
.....									
	3200 6400	3400 6200	3600 6000	3800 5800	4000 5600	4200 5400	4400 5200	4600 5000	4800 4800
AZIMUTH OF TARGET - MILS									

- NOTES - 1. WHEN ENTERING FROM THE TOP USE THE SIGN BEFORE THE NUMBER.
 2. WHEN ENTERING FROM THE BOTTOM USE THE SIGN AFTER THE NUMBER.
 3. AZIMUTH IS MEASURED CLOCKWISE FROM NORTH.
 4. CORRECTIONS ARE FOR 0 DEGREES LATITUDE. FOR OTHER LATITUDES
 MULTIPLY CORRECTIONS BY THE FACTOR GIVEN BELOW.

LATITUDE (DEG)	10	20	30	40	50	60	70
MULTIPLY BY	.98	.94	.87	.77	.64	.50	.34

Figure 10-22. Table H.

The sign associated with the correction is minus when entering from the top and plus when entering from the bottom. The value extracted is for 0 degrees latitude and must be modified by a correction factor shown below the table. Record correction factors as shown in figure 10-23.

CHART DIRECTION OF WIND		L		R		KNOTS		UNIT CORR		CROSS WIND	
CROSS WIND	WIND SPEED	* COMP		=		KNOTS		UNIT CORR		CROSS WIND	R
RANGE WIND	WIND SPEED	* COMP		=		TAIL HEAD		KNOTS		MET DEFL	L
RANGE WIND	WIND SPEED	* COMP		=		TAIL HEAD		KNOTS		MET DEFL	R
MET RANGE CORRECTION											
	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS					
RANGE WIND	11.	0	11	+ 7.5							
AIR TEMP	101.2	100%	1.2	- 6.1							
AIR DENSITY	97.7	100%	2.3	- 6.1							
PROJ WEIGHT	30	40	10	- 31.0							
ROTATION	- 7 X	.87									
MET RANGE CORR											
COMPUTATION OF VE											
PROP TEMP	VE	CHANGE TO MV FOR PROP TEMP	M/S	MV UNIT CORRECTION	TOTAL RANGE CORRECTION						
					MET RANGE CORRECTION						
					ΔV RANGE CORRECTION						
					RANGE						

Figure 10-23. Rotation correction (range).

p. Enter table I (fig 10-24) with the entry range and azimuth of fire expressed to the nearest 100 mils. Table I lists correction factors to azimuth for rotation. Each page contains a table for the appropriate latitude. For northern latitudes, enter the table from the top. For southern latitudes, enter it from the bottom. Enter the sign before the number when entering from the top. Enter the sign after the number when entering from the bottom. Extract the appropriate value and record as shown in figure 10-25.

FT 155-AM-2

TABLE I

CHARGE
4GPROJ. HE, M107
FUZE, PD, M557

ROTATION - AZIMUTH

CORRECTIONS TO AZIMUTH, IN MILS, TO COMPENSATE
FOR THE ROTATION OF THE EARTH

30 DEGREES NORTH LATITUDE

RANGE METERS	AZIMUTH OF TARGET - MILS									
	0 6400	400 6000	800 5600	1200 5200	1600 4800	2000 4400	2400 4000	2800 3600	3200 3200	
500	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	
1000	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	L0.1R	
1500	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	
2000	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	L0.2R	L0.3R	L0.3R	
2500	L0.3R	L0.3R	L0.3R	L0.3R	L0.3R	L0.3R	L0.3R	L0.3R	L0.3R	
3000	L0.3R	L0.3R	L0.3R	L0.4R	L0.4R	L0.4R	L0.4R	L0.4R	L0.4R	
3500	L0.4R	L0.4R	L0.4R	L0.4R	L0.4R	L0.5R	L0.5R	L0.5R	L0.5R	
4000	L0.4R	L0.4R	L0.5R	L0.5R	L0.5R	L0.5R	L0.6R	L0.6R	L0.6R	
4500	L0.5R	L0.5R	L0.5R	L0.5R	L0.6R	L0.6R	L0.6R	L0.7R	L0.7R	
5000	L0.5R	L0.5R	L0.6R	L0.6R	L0.7R	L0.7R	L0.7R	L0.8R	L0.8R	
5500	L0.6R	L0.6R	L0.6R	L0.7R	L0.7R	L0.8R	L0.8R	L0.9R	L0.9R	
6000	L0.6R	L0.6R	L0.7R	L0.7R	L0.8R	L0.9R	L1.0R	L1.0R	L1.0R	
6500	L0.7R	L0.7R	L0.7R	L0.8R	L0.9R	L1.0R	L1.1R	L1.1R	L1.2R	
7000	L0.7R	L0.7R	L0.8R	L0.9R	L1.0R	L1.1R	L1.2R	L1.3R	L1.3R	
7500	L0.7R	L0.8R	L0.9R	L1.0R	L1.1R	L1.3R	L1.4R	L1.5R	L1.6R	
8000	L0.7R	L0.8R	L0.9R	L1.1R	L1.3R	L1.6R	L1.7R	L1.9R	L1.9R	
8000	L0.5R	L0.6R	L0.8R	L1.2R	L1.6R	L2.1R	L2.4R	L2.7R	L2.7R	
7500	L0.3R	L0.4R	L0.7R	L1.2R	L1.8R	L2.3R	L2.8R	L3.2R	L3.3R	
7000	0.0	L0.1R	L0.5R	L1.1R	L1.8R	L2.5R	L3.1R	L3.5R	L3.7R	
6500	R0.3L	R0.1L	L0.4R	L1.1R	L1.9R	L2.7R	L3.4R	L3.9R	L4.0R	
6000	R0.5L	R0.4L	L0.2R	L1.0R	L1.9R	L2.9R	L3.7R	L4.2R	L4.4R	
5500	R0.9L	R0.6L	0.0	L0.9R	L1.9R	L3.0R	L3.9R	L4.5R	L4.7R	
5000	R1.2L	R0.9L	R0.3L	L0.8R	L2.0R	L3.2R	L4.2R	L4.9R	L5.1R	
4500	R1.5L	R1.3L	R0.5L	L0.6R	L2.0R	L3.3R	L4.4R	L5.2R	L5.4R	
	3200 3200	2800 3600	2400 4000	2000 4400	1600 4800	1200 5200	800 5600	400 6000	0 6400	

AZIMUTH OF TARGET - MILS

30 DEGREES SOUTH LATITUDE

- NOTES - 1. WHEN ENTERING FROM THE TOP USE THE SIGN BEFORE THE NUMBER.
 2. WHEN ENTERING FROM THE BOTTOM USE THE SIGN AFTER THE NUMBER.
 3. R DENOTES CORRECTION TO THE RIGHT, L TO THE LEFT.
 4. AZIMUTH IS MEASURED CLOCKWISE FROM THE NORTH.

Figure 10-24. Table I.

WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD		6400		TOT DF CORR L2		ROTATION $\odot$ 0.5	
DIRECTION OF WIND		5900		-MET DF CORR		DRIFT CORR $\odot$ 6.2	
DIRECTION OF WIND		0400		POS DF CORR			
CHART DIRECTION OF WIND		5500					
CROSS WIND	WIND SPEED	17	* CORR R	77	* CORR L	13	KNOTS * UNIT CORR
RANGE WIND	WIND SPEED	17	* CORR R	463	* CORR L	11	KNOTS MET DEFL L CORR R

Figure 10-25. Rotation correction (azimuth).

g. Compute the met deflection correction by multiplying the crosswind unit correction factor (table F, column 9) by the crosswind value and recording as shown in figure 10-26. Then total the values for rotation, drift, and crosswind and express to the nearest mil. This value represents that part of the total deflection correction due to measurable (met) conditions.

r. Compute the position deflection correction (constant) by subtracting the met deflection correction from the total deflection

correction. This value represents that part of the total deflection correction due to unmeasurable (position) conditions.

- s. Compute the met range correction by multiplying the variation from standard in the MET RANGE CORRECTION block by the unit correction factors. Record these values in the proper column (to the nearest 0.1). Add the columns. Algebraically add the smaller value to the larger value, and express the result to the nearest meter. Record as shown in figure 10-26.

MET DATA CORRECTION SHEET									
For use of this form, see FM 6-40; proponent agency is TRADOC.									
BATTERY DATA					MET MESSAGE				
CHARGE	ADJ GE	CHART RG	LATITUDE	TYPE MESSAGE	OCTANT	AREA/UNIT			
460	340	5140	30°N	MET B3	1	347 985			
ALT OF DTRY	(355)	360	DATE	TIME	ALT HOP	PRESSURE			
			27	1230	550	97.2			
ALT OF HOP		550	LINE NO	WIND DIR	WIND SPEED	AIR TEMP	AIR DENSITY		
			02	5900	17	100.8	95.8		
DTN ABOVE HOP (AN)		190	A & B CORRECTION			0.4 0.19			
ALT OF TARGET (nearest meter)		376	CORRECTED VALUES			101.2 97.7			
HEIGHT OF BURST ABOVE TARGET									
ALT OF BURST		376							
ALT OF DTRY (nearest meter)		355							
HEIGHT OF TARGET (Burst) ABOVE GUN (R)		+21 ≈ 0	COMP RG	CHART RG	ENTRY RG	5100			
			+0	5140	5140				
WIND COMPONENTS AND DEFLECTION									
WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD		8400		TOTAL OF CORR L2					
DIRECTION OF WIND		5900		- MET DF CORR L9					
DIRECTION (6395)		0400		POS DF CORR R7					
CHART DIRECTION OF WIND		5500		ROTATION CORR		0.5			
				DRIFT CORR		06.2			
CROSS WIND	WIND SPEED	17	COMP	0.77	0.13	KNOTS	UNIT CORR	CROSS WIND CORR	02.5
RANGE WIND	WIND SPEED	17	COMP	0.63	0.11	KNOTS	UNIT CORR	MET DEFL CORR	9.2
MET RANGE CORRECTION									
	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS			
RANGE WIND	0 11	0	0 11	+7.5	02.5				
AIR TEMP	101.2	100%	0 1.2	-6.1		7.3			
AIR DENSITY	97.7	100%	0 2.3	-6.1		14.0			
PROJ WEIGHT	30	40	0 10	-31.0		31.0			
ROTATION	-7X	.87				6.1			
					02.5	58.4			
					-58.4				
					24.1	124			
COMPUTATION OF VE									
PROF TEMP	+82	VE	W/S	+24.9	TOTAL RANGE CORRECTION	+1240			
		CHANGE TO MV FOR PROF TEMP	W/S	-19.5	MET RANGE CORRECTION				
			MV UNIT CORRECTION		AV RANGE CORRECTION				
					TOTAL RANGE CORRECTION				

Figure 10-26. Met deflection correction and position deflection correction.

t. Compute position velocity error. The total range correction represents the correction for all nonstandard conditions. The met range correction represents the correction for met nonstandard conditions. The ΔV range correction represents what is left and is determined by algebraically subtracting the met range correction from the total range correction. The symbol ΔV represents the total variation from the standard muzzle velocity, and the ΔV range correction represents the magnitude of the correction, in meters, required to offset the variation in muzzle velocity. Since MV is measured in meters per second, the ΔV range correction must be converted from meters to meters per second to express the total variation from standard (ΔV). The conversion is accomplished by dividing the ΔV range correction by the appropriate MV unit correction factor extracted from table F. Determining which correction factor to use requires a complete understanding of the ΔV range correction. A positive ΔV range correction shows that an increase in range is needed. It follows that the velocity developed was not enough to achieve the range desired. Therefore, the MV was less than standard, or a decrease. Since the velocity was a decrease value, the decrease unit correction factor is used. The unit correction factor indicates how many meters correction is necessary for each 1-meter-per-second decrease from the standard. When the MV decreases from standard, a plus range correction is needed. When the MV increases from standard, a minus range correction is needed. In this sample problem, a plus ΔV range correction has been determined (+216), indicating a decrease in muzzle velocity (fig 10-27). The ΔV range correction (+216) is divided by the MV unit correction factor (+24.9) to determine the amount of decrease in muzzle velocity. The result is expressed to the nearest one-tenth of a meter per second. Since the MV has been determined to be a decrease from standard, the variation must be a minus, yielding a -8.7 ΔV . ΔV represents the total variation from the standard muzzle velocity. This total variation is made up of propellant temperature effect, which can be measured; the position VE, which is due to elements that cannot be easily measured (for example, chart errors, survey errors, tube wear, and projectile ballistic coefficient); and muzzle velocity variation. Since the total (ΔV) is

known (-8.7) and a part (+0.5) due to propellant temperature is known, the remaining part (VE) can be determined by algebraically subtracting the change to MV for propellant temperature from ΔV ($[-8.7 \text{ m/s}] - [+0.5 \text{ m/s}] = [-9.2 \text{ m/s}]$). The position VE is determined by algebraically subtracting the value of the MVV from the VE ($[-9.2 \text{ m/s}] - [-7.7 \text{ m/s}] = [-1.5 \text{ m/s}]$). The VE, as determined above, may change over

time but is considered valid until a new VE is determined from a later registration and concurrent met or a new MVV is determined. The VE is the sum of the MVV and position VE ($[-1.5 \text{ m/s}] + [-7.7 \text{ m/s}] = [-9.2 \text{ m/s}]$). The MVV is constantly updated (chap 13). However, the position VE is a constant for all projectile combinations in that firing position except for the M712 Copperhead projectile.

MET DATA CORRECTION SHEET									
For use of this form, see FM 6-40; proponent agency is TRADOC.									
BATTERY DATA					MET MESSAGE				
CHARGE	ADJ QE	CHART RG	LATITUDE	TYPE MESSAGE	OCTANT	AREA/UNIT			
ALT OF BTRY (m)	360	DATE	TIME	ALT MGR	PRESSURE				
ALT OF MGR	550	LINE NO.	WIND DIR	WIND SPEED	AIR TEMP				
BTRY ABOVE MGR (m)	190	A & B CORRECTION		0.4 0.19					
ALT OF TARGET (nearest meter)	376	CORRECTED VALUES		101.2 97.7					
HEIGHT OF BURST ABOVE TARGET	-								
ALT OF BURST	376								
ALT OF BTRY (nearest meter)	355								
HEIGHT OF TARGET (nearest meter) ABOVE GUN (m)	+216	COMP RG	CHART RG	ENTRY RG	5100				
WIND COMPONENTS AND DEFLECTION									
WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD	800	TOTAL DEF CORR L2							
DIRECTION OF WIND	5900	- MET DEF CORR L9							
DIRECTION (0395)	0400	POS DEF CORR R7							
CHART DIRECTION OF WIND	5500	NOTATION CORR 0.5							
CROSS WIND	17	COMP	13	KNOTS	19	CROSS WIND CORR	0.5		
RANGE WIND	17	COMP	11	KNOTS	19	NET DEF CORR	0.2	L9	
MET RANGE CORRECTION									
	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS			
RANGE WIND	11	0	11	+7.5	82.5				
AIR TEMP	101.2	100%	1.2	-6.1	7.3				
AIR DENSITY	97.7	100%	2.3	-6.1	14.0				
PROJ WEIGHT	3	4	10	-31.0	31.0				
ROTATION					6.1				
VE - MUV = POS VE					82.5	58.4			
-9.2 - (-7.7) = -1.5					58.4				
					24.1		+24		
COMPUTATION OF VE									
PROP TEMP	VE	-9.2	W/S	+24.9	TOTAL RANGE CORRECTION	+240	(W)		
	CHANGE TO MV FOR PROP TEMP	+0.5	W/S	-19.5	MET RANGE CORRECTION	+24	(P)		
	ΔV	-8.7	W/S	+24.9	AV RANGE CORRECTION	+216	(P)		
OLD VE					NEW VE				

Figure 10-27. Met range correction and position velocity error.

u. Enter variations from standard in the MET FUZE CORRECTION block (fig 10-28).

COMPUTATION OF VE					
PROP TEMP	VE				TOTAL RANGE CORRECTION
	CHANGE TO MV FOR PROP TEMP		M/S		MET RANGE CORRECTION
	ΔV		M/S	MV UNIT CORRECTION	ΔV RANGE CORRECTION
					TOTAL RANGE CORRECTION
OLD VE _____ NEW VE _____ = _____ - 2 = AVG VE _____ M/S					
MET FUZE CORRECTION					
	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS	
ΔV	8.7				5380 +240
RANGE WIND	11				5140 335 18.9
AIR TEMP	1.2				-1.0
AIR DENSITY	2.3				19.9
PROJ WEIGHT	1.7				
					TOTAL FUZE CORRECTION
					MET FUZE CORRECTION
					FUZE CORRECTION
					TOTAL FUZE CORRECTION
MET FUZE CORR					
OLD FZ CORR _____ NEW FZ CORR _____ - 2 = AVG FZ CORR _____					
TARGET NO. REG PT 2		BATTERY A		DATE TIME 5/22/84	

DA FORM 4200 1 JAN 74 REPLACES DA FORM 6 15, 1 APR 67, WHICH IS OBSOLETE

Figure 10-28. Entering variations from standards.

v. Enter table J (fig 10-29) with the fuze setting corresponding to the adjusted elevation expressed to the nearest whole fuze setting increment, and determine unit corrections. Extract the values from the appropriate increase or decrease column.

w. Enter unit corrections from table J in the MET FUZE CORRECTION block (fig 10-30).

x. Compute the met fuze correction in the same manner as the met range correction (fig 10-30).

CHARGE
4GTABLE J
FUZE CORRECTION FACTORSFT 155-AM-2
PROJ, HE, M557
FUZE, MTSQ, M564

1	2	3	4	5	6	7	8	9	10	11
FS	FUZE CORRECTIONS FOR									
	MUZZLE VELOCITY 1 M/S		RANGE WIND 1 KNOT		AIR TEMP 1 PCT		AIR DENSITY 1 PCT		PROJ WT OF 1 SQ (4 SQ STD)	
	DEC	INC	HEAD	TAIL	DEC	INC	DEC	INC	DEC	INC
0										
1										
2	-.006	.006	-.000	.000	-.001	.000	.000	.000	.011	-.011
3	-.009	.009	-.001	.000	-.001	.001	.000	.000	.015	-.015
4	-.012	.011	-.001	.000	-.003	.001	.000	.000	.020	-.020
5	-.014	.013	-.001	.001	-.004	.002	.001	-.001	.024	-.024
6	-.017	.016	-.002	.001	-.005	.003	.001	-.001	.028	-.028
7	-.020	.018	-.002	.001	-.007	.003	.001	-.001	.031	-.032
8	-.022	.020	-.003	.001	-.009	.004	.002	-.001	.035	-.036
9	-.025	.022	-.004	.002	-.010	.004	.002	-.002	.039	-.040
10	-.027	.024	-.004	.002	-.012	.005	.002	-.002	.042	-.044
11	-.030	.026	-.005	.002	-.014	.006	.003	-.003	.045	-.047
12	-.032	.028	-.006	.002	-.015	.007	.003	-.003	.049	-.051
13	-.035	.030	-.006	.003	-.017	.007	.004	-.004	.052	-.055
14	-.037	.032	-.007	.003	-.018	.008	.004	-.004	.055	-.059
15	-.039	.034	-.007	.003	-.020	.008	.005	-.004	.059	-.062
16	-.042	.036	-.008	.003	-.022	.009	.005	-.005	.062	-.066
17	-.044	.038	-.009	.004	-.023	.010	.006	-.006	.065	-.070
18	-.047	.040	-.009	.004	-.025	.010	.006	-.006	.068	-.073
19	-.049	.042	-.010	.004	-.026	.011	.007	-.007	.071	-.077
20	-.052	.044	-.010	.004	-.027	.011	.008	-.007	.074	-.081
21	-.054	.046	-.011	.005	-.029	.012	.008	-.008	.078	-.084
22	-.057	.048	-.011	.005	-.030	.012	.009	-.009	.081	-.088
23	-.059	.050	-.012	.005	-.031	.013	.010	-.009	.084	-.091
24	-.062	.052	-.012	.005	-.032	.013	.010	-.010	.087	-.095
25	-.064	.054	-.013	.006	-.034	.014	.011	-.011	.090	-.099
26	-.067	.056	-.013	.006	-.035	.014	.012	-.012	.093	-.103
27	-.069	.059	-.013	.006	-.036	.014	.013	-.012	.096	-.107
28	-.072	.061	-.014	.006	-.037	.015	.013	-.013	.100	-.110
29	-.074	.063	-.014	.006	-.038	.015	.014	-.014	.103	-.114
30	-.077	.065	-.015	.007	-.039	.015	.015	-.015	.107	-.118
31	-.079	.067	-.015	.007	-.040	.016	.016	-.016	.110	-.121
32	-.082	.070	-.015	.007	-.041	.016	.017	-.016	.114	-.125
33	-.084	.072	-.015	.007	-.041	.016	.018	-.017	.118	-.128
34	-.087	.074	-.016	.007	-.042	.017	.019	-.018	.122	-.132
35	-.089	.077	-.016	.008	-.043	.017	.019	-.019	.127	-.135

Figure 10-29. Table J.

NET FUZE CORRECTION				
	VARIA- TION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS
AV	8.7	-0.052		
RANGE WIND	11	-0.010		
AIR TEMP	1.2	+0.011		
AIR DENSITY	2.3	+0.008		
PROJ WEIGHT	1.4	+0.074		
				TOTAL FUZE CORRECTION
				-1.0

5300
+240
5140 3.35 18.9
19.9
-1.0

Figure 10-30. Entering unit correction values.

MET FUZE CORRECTION					
	VARIA- TION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS	
ΔV	8.7	-.052	/	.452	5380 +240
RANGE WIND	11	-0.010	/	.110	5140 335 18.9
AIR TEMP	1.2	+0.011	0.013	/	✓ -1.0
AIR DENSITY	2.3	+0.008	0.018	/	19.9
PROJ WEIGHT	10	+0.074	0.074	.562	TOTAL FUZE CORRECTION -1.0 (w)
			0.105	.105	MET FUZE CORRECTION -0.5 (P)
				.457	FUZE CORRECTION -0.5 (P)
				≈ -0.5	TOTAL FUZE CORRECTION
MET FUZE CORR					
OLD FZ CORR _____ + NEW FZ CORR _____ = _____ - 2 = AVG FZ CORR _____					
TARGET NO. REG PT 2		BATTERY A		DATE/TIME 5/22/84 1400	
DA FORM 4200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE					

Figure 10-31. Fuze correction factors and met fuze correction.

y. Compute the position fuze correction (constant) by algebraically subtracting the met fuze correction from the total fuze correction as shown in figure 10-31. A completed concurrent met is shown in figure 10-32.

Note. The position fuze correction (constant) determined should be considered a fuze characteristic, not a correction for existing weather conditions.

10-13. POSITION CONSTANTS

The purpose in solving a concurrent met is to isolate the position constants. These constants can be used later with subsequent mets to obtain met + VE GFT settings without conducting another registration.

a. When a registration is fired and a concurrent met (valid ballistic met) is available, the met will be solved to determine position constants. Position constants are considered valid only for the position in which they are determined.

MET DATA CORRECTION SHEET									
For use of this form, see FM 6-40; proponent agency is TRADOC.									
BATTERY DATA					MET MESSAGE				
CHARGE	ADJ Q	CHART RG	LATITUDE	TYPE MESSAGE	OCTANT	AREA/UNIT			
468	340	5140	30°N	MET B3	1	347995			
ALT OF BTRY (19°)	(355)	360	27	1230	550	97.2			
ALT OF MOP		550	02	5900	17	100.8 95.8			
STR. ABOVE (LN)		190	A & B CORRECTION		0.4		0.19		
ALT OF TARGET (nearest meter)		376	CORRECTED VALUES		101.2		97.7		
HEIGHT OF BURST ABOVE TARGET		-							
ALT OF BURST		376							
ALT OF BTRY (nearest meter)		355							
HEIGHT OF TARGET (nearest meter) ABOVE GUN (20)		+21 ± 0	COMP RG	CHART RG	ENTRY RG	5100			
WIND COMPONENTS AND DEFLECTION									
WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD		6400							
DIRECTION OF WIND		5900							
DIRECTION (0395)		0400							
CHART DIRECTION OF WIND		5500							
CROSS WIND	WIND SPEED	17	COMP	0.77	0.13	KNOTS	0.19	UNIT CORR	
RANGE WIND	WIND SPEED	17	COMP	0.63	0.11	KNOTS	0.11	UNIT CORR	
MET RANGE CORRECTION									
	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS			
RANGE WIND	0.11	0	0.11	+7.5	82.5				
AIR TEMP	101.2	100%	1.2	-6.1		7.3			
AIR DENSITY	97.7	100%	2.3	-6.1		14.0			
PROJ HEIGHT	30	40	10	-31.0		31.0			
ROTATION	-7X.87					6.1			
					82.5	58.4			
					58.4				
					24.1	+24			
COMPUTATION OF VE									
PROP TEMP	VE	-9.2	M/S	24.9	TOTAL RANGE CORRECTION	+240 (w)			
	CHANGE TO MV FOR PROJ TEMP	+0.5	M/S	19.5	MET RANGE CORRECTION	+24 (P)			
	SV	-8.7	M/S	24.9	SV RANGE CORRECTION	+216 (P)			
					TOTAL RANGE CORRECTION				
OLD VE _____ NEW VE _____ 2 AVG VE _____ M/S									
F5~ADJEL=19.9~200 MET FUZE CORRECTION									
	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS					
AV	0.87	-0.052		0.452					
RANGE WIND	0.11	-0.010		0.110					
AIR TEMP	1.2	+0.011	0.013						
AIR DENSITY	2.3	+0.008	0.018						
PROJ HEIGHT	10	+0.074	0.074						
				0.105	0.562				
				0.105	0.105				
				0.457	0.457				
MET FUZE CORR					TOTAL FUZE CORRECTION	-1.0 (w)			
					MET FUZE CORRECTION	-0.5 (P)			
					FUZE CORRECTION	-0.5 (P)			
					TOTAL FUZE CORRECTION				
OLD FZ _____ NEW FZ CORR _____ 2 AVG FZ CORR _____									
TARGET		BATTERY		DATE TIME					
REG PT 2		A		5/22/84		1400			
DA FORM 4200 REPLACES DA FORM 615, 1 APR 67, WHICH IS OBSOLETE									

Figure 10-32. Completed concurrent met.

b. When a unit has displaced to a new position and cannot register immediately, the MVV and the position fuze constant from the last position may be used as a basis to determine a met + VE GFT setting by solving a subsequent met. Use of this technique may incur slight inaccuracies, but it will produce the most accurate data possible until a registration can be conducted. Any fire mission that is used to determine total corrections is a registration. As soon as possible, new position constants based on

firing are determined in the new position. Once new position constants are determined, the position constants from the old position should not be used.

Note. The position deflection constant should not be transferred from an old position to a new position unless common survey directional control exists between positions.

Section IV

SUBSEQUENT MET

10-14. CHARACTERISTICS

A subsequent met is solved to determine new total corrections when registration is not possible. Solving a subsequent met produces new met corrections, which are added to the position corrections determined from the concurrent met. Adding the met and position corrections yields new total corrections that are used to determine a new GFT setting.

10-15. SEQUENCE FOR SOLUTION OF A SUBSEQUENT MET

Note. Asterisks indicate the values that may be the same as those for the concurrent met if the battery and met station have not moved. If the battery moves, the MVV and the position fuze correction will be valid in the new position. If common direction exists between positions, the position deflection correction is also valid in the new position.

a. Enter position deflection correction and position fuze correction, and compute and enter VE (position VE + MVV = VE).

b. Enter known data.

c. Enter met line number and met message data.

*d. Compute Δh and height of target above gun.

e. Compute chart direction of wind.

f. Enter tables and determine the following:

(1) Complementary range from table B.

(2) Wind components from table C.

* (3) Corrections to temperature and density from table D.

(4) Correction to MV for propellant temperature from table E.

*g. Compute corrected values for temperature, density, and entry range.

h. Compute crosswind and range wind.

i. Compute variations from standard.

j. Enter tables and determine the following:

(1) Unit corrections from table F.

* (2) Rotation corrections for range from table H.

* (3) Rotation corrections for azimuth from table I.

k. Compute met deflection correction and total deflection correction.

l. Compute met range correction, total range correction, and adjusted elevation.

m. Enter variations from standard in the MET FUZE CORRECTION block, and determine corrections from table J.

n. Compute met fuze correction and total fuze correction.

o. Determine GFT setting.

10-16. SOLUTION OF A SUBSEQUENT MET

The sample problem below describes the solution of a subsequent met by use of the steps outlined in paragraph 10-15. The position constants and known data from paragraph 10-12 will be used. The following met message is valid (notice that met station has moved):

METB31 342988 271450 029088
002216 951036

012320 950040

022621 942052

032921 941058

043125 940060

Propellant temperature +85° F

The updated MVV for charge 4GB, lot XY correction is -7.6 meters per second.

a. Enter the position deflection correction, enter the position fuze correction, and compute and enter VE as shown in figure 10-32.

b. Enter known data as shown in figure 10-33. The following data are always known data in a subsequent met if the battery and met station have not moved: charge, chart range, latitude, battery altitude, target altitude, altitude of the MDP, Δh corrections, height of target above gun, comp range, entry range, direction of fire, crosswind unit correction factor, drift correction, rotation correction, projectile weight, propellant temperature, and values for a decrease or increase in muzzle velocity. In this problem, the met station has moved, so MDP altitude and Δh have changed.

MET DATA CORRECTION SHEET										
For use of this form, see FM 6-40; proponent agency is TRADOC.										
BATTERY DATA					MET MESSAGE					
CHARGE	ADJ. Q	CHART NO.	LATITUDE	TYPE MESSAGE	OCTANT	AREA/UNIT				
4GB		5140	36°N	MET B3	1	342 988				
ALT OF BTRY (1000)		360		DATE	TIME	ALT MDP	PRESSURE			
		290		27	1430	290	108.8			
ALT OF MDP				LINE NO.	WIND DIR	WIND SPEED	AIR TEMP	AIR DENSITY		
				02	2600	21	94.2	105.2		
BTRY ABOVE MDP (AN)				A & B CORRECTION						
ALT OF TARGET (nearest meter)		376		CORRECTED VALUES						
HEIGHT OF BURST ABOVE TARGET										
ALT OF BURST		376								
ALT OF BTRY (nearest meter)		355								
HEIGHT OF TARGET (true) ABOVE GUN (AO)		+2120	COMP. RG	0	CHART NO.	5140	ENTRY NO.	5140	5100	
WIND COMPONENTS AND DEFLECTION										
WHEN DIRECTION OF WIND IS LESS THAN DR FIRE ADD				400						
DIRECTION OF WIND				POS DF CORR R7						
				MET DF CORR						
				TOT DF CORR						
DIRECTION (0345)				0400				ROTATION CORR		0.5
CHART DIRECTION OF WIND								DRIFT CORR		06.2
CROSS WIND	WIND SPEED	21	COMP. R		KNOTS	19	CROSS WIND CORR			
RANGE WIND	WIND SPEED	21	COMP. H		TAIL HEAD	KNOTS	MET DEFL CORR			
MET RANGE CORRECTION										
	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS				
RANGE WIND	T	0	T							
AIR TEMP		100%	D							
AIR DENSITY		100%	D							
PROJ. WEIGHT	30	40	D							
ROTATION	-7X	.87								
POS VE + MVV = VE										
-1.5 + (-7.6) = -9.1										
COMPUTATION OF VE										
PROP. TEMP	VE	-9.1	M/S	0 + 29.9	TOTAL RANGE CORRECTION					
	CHANGE TO MV FOR PROP. TEMP		M/S	-19.5	MET RANGE CORRECTION					
	AV		M/S		AV RANGE CORRECTION					
					TOTAL RANGE CORRECTION					
MET FUZE CORRECTION										
	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS						
AV	0									
RANGE WIND	T									
AIR TEMP	D									
AIR DENSITY	D									
PROJ. WEIGHT	D									
					TOTAL FUZE CORRECTION					
					MET FUZE CORRECTION					
					FUZE CORRECTION	-0.5				
					TOTAL FUZE CORRECTION					
DA FORM 4200 REPLACES DA FORM 6 15, 1 APR 67, WHICH IS OBSOLETE										
REGPT 2		BATTERY: A		DATE/TIME: 15 JUN 84 0800						

Figure 10-33. Known data.

MET DATA CORRECTION SHEET									
For use of this form, see FM 6-40; proponent agency is TRADOC.									
BATTERY DATA					MET MESSAGE				
CHARGE	ADJ. DE.	CHART NO.	LATITUDE	TYPE MESSAGE	OCTANT	AREA/UNIT			
428		5140	30°N	MET B3	1	342 988			
ALT OF STRY (10)	(348)	360	27	7430	290	108.8			
ALT OF MDP		290	02	2600	21	94.2			
STRY WIND		70	A & B CORRECTION		00.2	00.7			
ALT OF TARGET (nearest meter)		326	CORRECTED VALUES		94.0	104.5			
HEIGHT OF BURST ABOVE TARGET									
ALT OF BURST		326							
ALT OF STRY (nearest meter)		355							
HEIGHT OF TARGET (feet) ABOVE GUN (0)		721	0	5140	5140	5100			
WIND COMPONENTS AND DEFLECTION									
WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD		DOS DF CORR R7							
DIRECTION OF WIND		2600							
DIRECTION OF FIRE		0400							
CHART DIRECTION OF WIND		2200							
CROSS WIND	WIND SPEED	21	COMP	0.83	17	KNOTS	19	UNIT CORR	
RANGE WIND	WIND SPEED	21	COMP	0.56	12	KNOTS	12	UNIT CORR	
MET RANGE CORRECTION									
RANGE WIND	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS			
	12		12	-3.3		39.6			
AIR TEMP	94.0	100	6.0	+15.1	90.6				
AIR DENSITY	104.5	100	4.5	+6.2	27.9				
PROJ WEIGHT	30	40	10	-31.0		31.0			
ROTATION	-7 X	.87				6.1			
DOS VE + MVV = VE						118.5	76.7		
-1.5 + (-7.6) = -9.1						76.7			
						41.8		+42	
COMPUTATION OF VE									
PROP TEMP	VE	-9.1	(P)	+24.9	TOTAL RANGE CORRECTION				
	CHANGE TO MV FOR PROP TEMP	+0.6	(P)	+19.5	MET RANGE CORRECTION	+42	(P)		
	AV	-8.5	(W)	+24.9	AV RANGE CORRECTION	+212	(P)		
					TOTAL RANGE CORRECTION	+254	(W)		
MET FUZE CORRECTION									
AV	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS					
	0.5	-0.052		0.442	5390	18.9			
RANGE WIND	12	+0.009	0.048		250	336	-1.0		
AIR TEMP	96.0	-0.027		0.162	5140	19.9			
AIR DENSITY	104.5	-0.007		0.033					
PROJ WEIGHT	10	+0.074	0.074						
				0.22	0.636	MET FUZE CORRECTION	-0.5	(P)	
				0.122		FUZE CORRECTION	-0.5	(P)	
				0.514		TOTAL FUZE CORRECTION	-1.0	(W)	
DA FORM 4200 REPLACES DA FORM 615, 1 APR 67, WHICH IS OBSOLETE									
TARGET		BATTERY		DATE/TIME					
REG PT 2		A		3/22/84		1400			

Figure 10-34. Completed subsequent met.

c. Enter the met line number and met message data. Since an adjusted quadrant is unknown, use the met line number from the concurrent met. Record, as shown in figure 10-33, the data from the met message example at the beginning of this discussion. Also enter wind speed in the wind component block. If height of target above gun has changed from the concurrent met, determine and enter the value of comp range in the comp range block by using table B of the tabular firing table. Enter the table with the chart range expressed to the nearest 100 meters and the met line number used.

d. Compute Δh and height of target above gun. Since the met station has moved and its altitude has changed, Δh must be computed. The height of target above gun (VI) has not changed (fig 10-33).

e. Compute chart direction of wind as shown in figure 10-34.

f. Enter table B and extract the data in the same manner as in the concurrent met.

g. Enter table C and extract and record the data as shown in figure 10-34.

h. Enter table D and extract and record the corrections as shown in figure 10-34.

i. Enter table E and interpolate or extract the correction to muzzle velocity for propellant temperature and record as shown in figure 10-34.

j. Compute the corrected values for temperature and density by adding the values from table D to the met values. Record the result as shown in figure 10-34.

k. Compute the entry range by adding the comp range and chart values together.

l. Compute crosswind and range wind by multiplying the crosswind and range wind components by the wind speed. Record the results to the nearest knot as shown in figure 10-34.

m. Compute variations from standard. Record the corrected values for range wind, air temperature, and air density in the MET RANGE CORRECTION block. Compute variations from standard as shown in figure 10-34.

n. Enter table F and determine the unit corrections.

o. Enter table H and determine the rotation correction for range.

p. Enter table I and determine the rotation correction for azimuth.

q. Compute the met deflection correction in the same manner as in the concurrent met.

r. Compute the new total deflection correction by adding the position deflection correction and the met deflection correction.

s. Compute the met range correction as shown in figure 10-34.

t. Compute the total range correction. To determine a new total range correction, determine the ΔV range correction and add to the met range correction (fig 10-34.) First, determine the ΔV by adding the position VE to the current MVV for that charge and lot to determine the velocity error. Add the VE to the change to muzzle velocity for propellant temperature. Convert the ΔV to a ΔV range correction by multiplying ΔV by the appropriate MV unit correction factor. If ΔV is minus, use the decrease factor. If ΔV is plus, use the increase factor. Then add the ΔV range correction to the met range correction. Express the total range correction to the nearest 10 meters.

u. Compute the adjusted elevation by adding the total range correction to the chart

range. Set the MHL of the GFT over this range.

v. Enter variations from standard and determine values from table J (fig 10-34). Enter the variations from standard in the MET FUZE CORRECTION block, and extract the appropriate values. The entry argument for table J is the fuze setting corresponding to the adjusted elevation expressed to the nearest whole fuze setting increment.

w. Compute the met fuze correction and the total fuze correction. Determine the met fuze correction in the same manner as in the concurrent met (fig 10-34). To determine a total fuze correction, add the met fuze correction to the position fuze correction.

x. Determine the GFT setting. The new GFT setting is the same as the old one except for a new adjusted time and elevation. Determine the GFT deflection correction by subtracting drift corresponding to the new adjusted elevation from the new total deflection correction.

EXAMPLE:

GFT A: Chg 4, Lot XY, Rg 5140, El 336, Ti 18.9;

Tot Df Corr: R3

Drift $\approx$ Adj El 336 = L7

GFT Df Corr R4

Section V

SUBSEQUENT MET APPLICATIONS

10-17. EIGHT-DIRECTION MET

Certain combat conditions may require a firing unit to provide accurate artillery support throughout a 6,400-mil zone. Transfer limits define an area within which registration corrections are assumed to be valid. These transfer limits place a severe limitation on a 6,400-mil firing capability.

Registration corrections may be obtained by conducting a registration in each 800-mil sector of the unit's area of responsibility. Such registrations, however, would be costly and would endanger unit survivability. Ballistic computers (BCS, FADAC, and TACFIRE) provide corrected firing data throughout 6,400 mils. These computers can also provide data for use in determining a GFT setting and a GFT deflection correction

for each 800-mil segment of a unit's area of responsibility. However, when BCS or FADAC is not available, a manual solution for determining corrections throughout 6,400 mils must be used. The application of current registration or met + VE corrections produces accurate results within range and deflection transfer limits. The 6,400-mil capability can be provided by conducting a registration or by calculating a GFT setting for each 800-mil sector by use of the met + VE technique.

a. The eight-direction met procedure provides corrections to range, deflection, and fuze setting to compensate for the effects of ballistic wind direction and velocity and for rotation of the earth throughout the firing unit's area of responsibility. When these corrections are combined with known position corrections, lateral transfer limits can be eliminated for ranges of 10,000 meters or less (fig 10-35). For ranges greater than 10,000 meters, there will be areas between the 800-mil segments that are not covered by valid corrections, because the lateral transfer limits are valid 4,000 meters right and 4,000 meters left of the battery registration point.

When needed, corrections must be computed by use of a met to a target to cover these areas. (Procedures for solving a met to a target are discussed in paragraph 10-19.) The eight-direction met technique consists of two steps:

(1) Solution of a met message concurrent with a registration to determine the position VE, position deflection correction, and position fuze correction.

(2) Solution of a met message for other 800-mil segments by use of the met + VE technique and the position VE, position deflection correction, and position fuze correction to determine the GFT settings for those octants.

Note. The major change is the direction of fire for each octant and its effect on wind and rotation corrections.

b. Using the known data from paragraph 10-16, the FDO decides to determine a GFT setting for octant II, 800 mils to the right (fig 10-36).

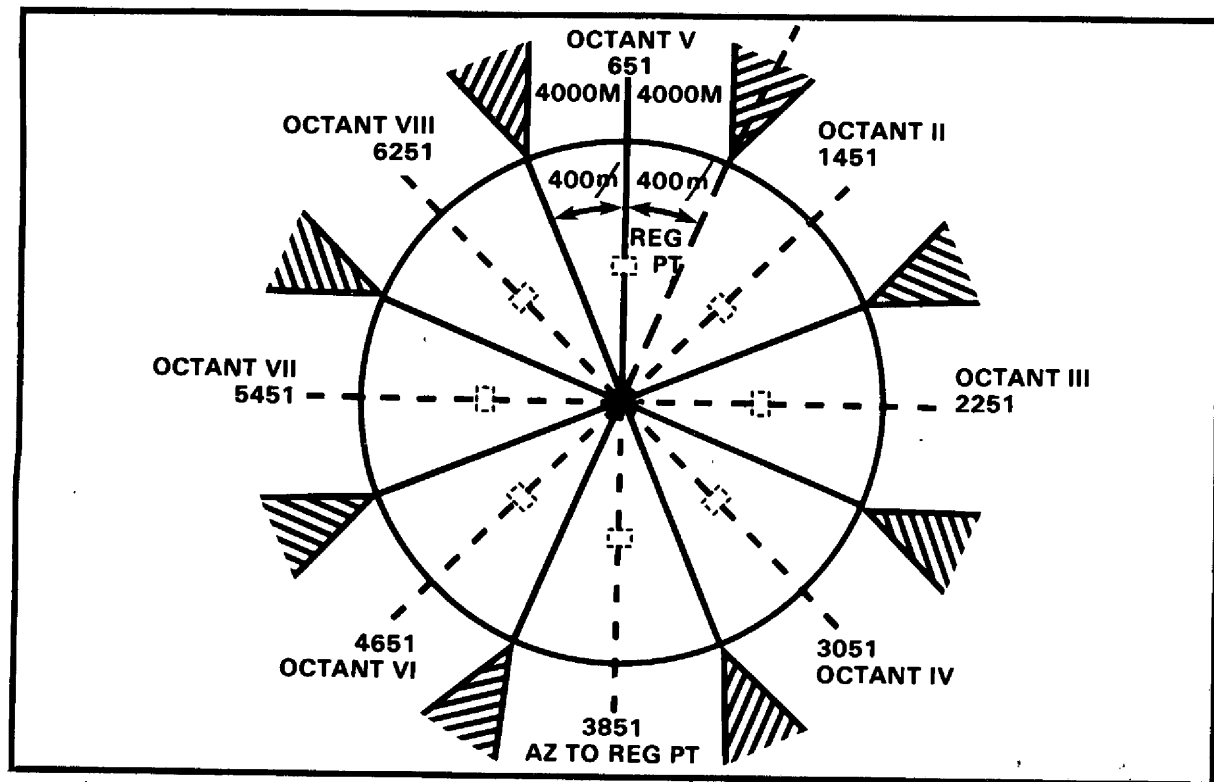


Figure 10-35. Met octants.

MET DATA CORRECTION SHEET									
For use of this form, see FM 6-40; proponent agency is TRADOC.									
BATTERY DATA					MET MESSAGE				
CHARGE	ADJ. DE	CHART NO.	LATITUDE	TYPE MESSAGE	OCTANT	AREA/UNIT			
408		5140	30N	MET 63	1	392988			
ALT OF STRY (10 m)		360		DATE	TIME	ALT MDP	PRESSURE		
				27	1430	290	108.8		
ALT OF MDP		290		LINE NO.	WIND DIR	WIND SPEED	AIR TEMP	AIR DENSITY	
				02	2600	21	94.2	105.2	
STRY BELOW (AN)		+70		A & B CORRECTION		00.2		0.7	
ALT OF TARGET (nearest meter)		355		CORRECTED VALUES		94.0		104.5	
HEIGHT OF BURST ABOVE TARGET									
ALT OF BURST		355							
ALT OF STRY (nearest meter)		355							
HEIGHT OF TARGET (Range) ABOVE GUN (M)		0		COMP NO.	CHART NO.	ENTRY NO.	5100		
				0	5140	5140			
WIND COMPONENTS AND DEFLECTION									
WHEN DIRECTION OF WIND IS LESS THAN OUR FIRE ADD		S400		Pos DF CORR R7					
DIRECTION OF WIND		2600		MGT DF CORR L3					
				TOT DF CORR R4					
DIRECTION OF (H95)		1200		ROTATION CORR		0.6			
CHART DIRECTION OF WIND		1400		DRIFT CORR		0.6.2			
CROSS WIND	WIND SPEED	21	* CORR	0.98	21	KNOTS	19	CROSS WIND CORR	0.4.0
RANGE WIND	WIND SPEED	21	* CORR	0.20	4.0	KNOTS	4.0	MET DEF CORR	2.8 L3
MET RANGE CORRECTION									
	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	P. L.S.	MINUS			
RANGE WIND	04	0	04	+7.5	30.0				
AIR TEMP	94.0	100	06.0	+15.1	90.6				
AIR DENSITY	104.5	100	04.5	+6.2	27.9				
PROJ HEIGHT	30	40	10	-31.0		31.0			
ROTATION	-17	X	.87			14.8			
Pos VE + MVV = VE					148.5				
-1.5 + (-7.6) = -9.1					45.8				
					MET RANGE CORR				
					102.7				
COMPUTATION OF VE									
PROP TEMP	VE	-9.1	M/S	D	24.9	TOTAL RANGE CORRECTION			
	CHANGE TO MV FOR PROP TEMP	+0.6	M/S		-19.5	MET RANGE CORRECTION	+103		
	SV	-8.5	M/S			SV RANGE CORRECTION	+212		
						TOTAL RANGE CORRECTION	+315		
OLD VE _____ NEW VE _____ 2 AVG VE _____ M/S									
FS ~ ADJCEL = 203 ~ 20 MET FUZE CORRECTION									
	VARIATION FROM STANDARD	UNIT CORRECTION	PLUS	MINUS					
AV	08.5	-0.052		442	5460				
RANGE WIND	04	-0.010		040	+320 / 1				
AIR TEMP	6.0	-0.027		162	5140 342				
AIR DENSITY	04.5	-0.007		032	19.1				
PROJ HEIGHT	10	+0.074	.074		20.2 -1.1				
				.074	.076	MET FUZE CORRECTION	-0.6		
					.074	FUZE CORRECTION	-0.5		
					.602	TOTAL FUZE CORRECTION	-1.1		
OCTANT II A DATE 5/22/84									
DA FORM 4200 REPLACES DA FORM 15 1 APR 67 WHICH IS OBSOLETE									

Figure 10-36. Eight-direction met.

(1) Known or unchanged data from concurrent met are recorded.

(2) Target altitude is the same as the battery altitude.

(3) Met line number is the same as that in the concurrent met.

(4) The fuze setting corresponding to new adjusted elevation yields the same entry argument for table J. This entry argument may change.

(5) GFT setting for octant II is as follows:

GFT A: Chg 4, Lot XY, Rg 5140, El 342, Ti -19.3.

GFT Df Corr = total - drift

$R11 = R4 - L7$

(4) The GFT settings to the two met check gage points are as follows:

GFT A: Chg 4, Lot XY, Rg 3730, El 225, Ti 12.8

GFT A: Chg 4, Lot XY, Rg 5580, El 374, Ti 21.0

(5) The GFT setting from the registration is:

GFT A: Chg 4, Lot XY, Rg 5140, El 335, Ti 18.9

(6) The average GFT deflection correction is $R4: (R5) + (R5) + (R2) = R12 \div 3 = R4$.

(7) The average total deflection correction is $L2: (L2) + (R1) + (4) = L5 \div 3 = L1.67 \approx L2$.

(8) The multiplot GFT setting is applied to the GFT.

10-18. MET TO A MET CHECK GAGE POINT

a. When data from a registration and two met + VE computations to met check gage points are known, a more accurate GFT setting can be determined. When a three-plot GFT setting is constructed, it may be used for the full range of the GFT without regard to range transfer limits. Solution of the met to the met check gage point will yield a total range correction, a total deflection correction, and a total fuze correction at each met check gage point range. The met check gage points selected should be the ones farthest away (in range) from the registration point range that are usable.

b. Using the data from the concurrent met sample problem (para 10-12), the FDO decides to determine a multiplot GFT setting by using ranges 3730 (fig 10-37) and 5580 (fig 10-38) and the original range to the registration point.

(1) Target altitude is the same as the battery altitude.

(2) Met line number is determined from table B.

(3) Figures 10-37 and 10-38 show the completed met forms.

10-19. MET TO A TARGET

a. A met to a target must be completed if a target appears in an area not covered by a current GFT setting. The manual solution for a nuclear mission may also require the solution of a met to a target. A met to a target is solved by using the same procedures as those used in solving a subsequent met. The met message line number is determined from table B by using chart range to the target and VI expressed to the nearest 100 meters. The direction of fire is the chart direction to the target.

b. Assume a target is to be engaged in an area outside the octants for which GFT settings have been determined. Chart data to the target are as follows:

Target number	AA7079
Range	4100
Deflection	3853
Altitude	345

(1) Data that are known or unchanged from the concurrent met (para 10-12) should be recorded.

(2) The firing battery reports no change in propellant temperature.

(3) The met line number is determined from table B.

MET DATA CORRECTION SHEET									
For use of this form, see FM 6-40; proponent agency is TRADOC.									
BATTERY DATA					MET MESSAGE				
CHARGE	ADJ. DE	CHART NO.	LATITUDE	TYPE MESSAGE	OCTANT	AREA UNIT			
468		3730	30°N	MET 83	1	347985			
ALT OF STRY (10 m)	360	27	1230	550	97.2				
ALT OF MDP	550	01	5800	16	101.0	96.0			
STRY ABOVE MDP (AN)	190	A & B CORRECTION		0.4	1.9				
ALT OF TARGET (nearest meter)	355	CORRECTED VALUES		101.4	97.9				
HEIGHT OF BURST ABOVE TARGET									
ALT OF BURST	355								
ALT OF STRY (nearest meter)	355								
HEIGHT OF TARGET (burst) ABOVE GUN (M)	0	COMP NO.	CHART NO.	ENTRY NO.	3700				
WIND COMPONENTS AND DEFLECTION									
WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD									
DIRECTION OF WIND	5800	POS DF CORR R7 MET DF CORR L6 TOT DF CORR R1 - DFT L4							
DIRECTION (0395)	0400	ROTATION CORR		0.4					
CHART DIRECTION OF WIND	5400	DRIFT CORR		3.8					
CROSS WIND SPEED	16	COMP	83	13	KNOTS	14	CROSS WIND CORR	1.8	
RANGE WIND SPEED	16	COMP	56	9	KNOTS		MET DEF CORR	6.0	L6
MET RANGE CORRECTION									
RANGE WIND	9	KNOW VALUES	0	VARIATIONS FROM STANDARD	9	UNIT CORRECTIONS	45.9	MINUS	
AIR TEMP	101.4	100%	1.4	-4.5			6.3		
AIR DENSITY	97.9	100%	2.1	-3.4			7.1		
PROJ HEIGHT	30	40	10	-24.0			24.0		
ROTATION	-5	X	87				4.4		
								45.9	41.8
								41.8	
								4.1	+4
COMPUTATION OF VE									
PROP TEMP	+82	VE	-9.2	D	+18.6	TOTAL RANGE CORRECTION			
CHANGE TO MV FOR PROJ TEMP		SV	+0.5	W/S	14.7	MET RANGE CORRECTION	+4		
		SV	-8.7	W/S	MV UNIT CORRECTION +18.6	AV RANGE CORRECTION	+162		
						TOTAL RANGE CORRECTION	+166	+170	
FS ~ ADJ EL 36 ~ 14 MET FUZE CORRECTION									
AV	8.7	UNIT CORRECTION	-0.37	PLUS		MINUS			
RANGE WIND	9	-0.07					0.63		
AIR TEMP	1.4	+0.08					0.11		
AIR DENSITY	2.1	+0.04					0.08		
PROJ HEIGHT	10	+0.55					0.55		
						TOTAL FUZE CORRECTION	-0.3		
						MET FUZE CORRECTION	-0.5		
						FUZE CORRECTION	-0.8		
						TOTAL FUZE CORRECTION			
						3.11			
DA FORM 4200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE									

Figure 10-37. Met to a met check gage point—range 3730.

MET DATA CORRECTION SHEET									
For use of this form, see FM 6-40; proponent agency is TRADOC.									
BATTERY DATA					MET MESSAGE				
CHARGE	ADJ. DE	CHART NO.	LATITUDE	TYPE MESSAGE	OCTANT	AREA UNIT			
468		5580	30°N	MET 83	1	347985			
ALT OF STRY (10 m)	360	27	1230	550	97.2				
ALT OF MDP	550	02	5900	17	100.8	95.8			
STRY ABOVE MDP (AN)	190	A & B CORRECTION		0.4	1.9				
ALT OF TARGET (nearest meter)	355	CORRECTED VALUES		101.2	97.7				
HEIGHT OF BURST ABOVE TARGET									
ALT OF BURST	355								
ALT OF STRY (nearest meter)	355								
HEIGHT OF TARGET (burst) ABOVE GUN (M)	0	COMP NO.	CHART NO.	ENTRY NO.	5600				
WIND COMPONENTS AND DEFLECTION									
WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD									
DIRECTION OF WIND	5900	POS DF CORR R7 MET DF CORR L11 TOT DF CORR L4 - DFT							
DIRECTION (0395)	0400	ROTATION CORR		0.6					
CHART DIRECTION OF WIND	5500	DRIFT CORR		7.3					
CROSS WIND SPEED	17	COMP	77	13	KNOTS	21	CROSS WIND CORR	2.7	
RANGE WIND SPEED	17	COMP	63	11	KNOTS		MET DEF CORR	0.6	L11
MET RANGE CORRECTION									
RANGE WIND	11	KNOW VALUES	0	VARIATIONS FROM STANDARD	11	UNIT CORRECTIONS	91.3	MINUS	
AIR TEMP	101.2	100%	1.2	-6.6			7.9		
AIR DENSITY	97.7	100%	2.3	-7.3			16.8		
PROJ HEIGHT	30	40	10	-33.0			33.0		
ROTATION	-7	X	87				6.1		
								91.3	63.8
								63.8	
								27.5	+28
COMPUTATION OF VE									
PROP TEMP	+82	VE	-9.2	D	+27.2	TOTAL RANGE CORRECTION			
CHANGE TO MV FOR PROJ TEMP		SV	+0.5	W/S	-21.2	MET RANGE CORRECTION	+28		
		SV	-8.7	W/S	MV UNIT CORRECTION +27.2	AV RANGE CORRECTION	+237		
						TOTAL RANGE CORRECTION	+265	+260	
FS ~ ADJ EL 220 ~ 22 MET FUZE CORRECTION									
AV	8.7	UNIT CORRECTION	-0.57	PLUS		MINUS			
RANGE WIND	11	-0.11					12.1		
AIR TEMP	1.2	+0.12					0.14		
AIR DENSITY	2.3	+0.09					0.21		
PROJ HEIGHT	10	+0.81					0.81		
						TOTAL FUZE CORRECTION	-0.5		
						MET FUZE CORRECTION	-0.5		
						FUZE CORRECTION	-0.5		
						TOTAL FUZE CORRECTION	-1.0		
						1.501			
DA FORM 4200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE									

Figure 10-38. Met to a met check gage point—range 5580.

MET DATA CORRECTION SHEET									
For use of this form, see FM 6-40; proponent agency is TRADOC.									
BATTERY DATA					MET MESSAGE				
CHARGE	ADJ DE	CHART RG	LATITUDE	TYPE MESSAGE	DOYANT	AREA UNIT			
428		4100	50°N	MET 33	1	347985			
ALT OF STRY (IC)	(33)	360		DATE	TIME	ALT MDP	PRESSURE		
		550		27	1230	550	97.2		
ALT OF MDP				LINE NO.	WIND DIR	WIND SPEED	AIR TEMP	AIR DENSITY	
				01	5800	16	101.0	96.0	
STRY ABOVE MDP (AM)		190		A & B CORRECTION		00.4		01.9	
ALT OF TARGET (nearest meter)		345		CORRECTED VALUES		101.4		97.9	
HEIGHT OF BURST ABOVE TARGET									
ALT OF BURST		345							
ALT OF STRY (nearest meter)		355							
HEIGHT OF TARGET (bow) ABOVE GUN (M)		-10	20	COMP RG	CHART RG	ENTRY RG	4100		
WIND COMPONENTS AND DEFLECTION									
WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD		4400		DOS + MET = TOTAL					
DIRECTION OF WIND		5800		R7 + LS = R2					
DIRECTION OF FIRE		(5697) 5700		ROTATION CORR 0.5					
CHART DIRECTION OF WIND		0100		DRIFT CORR 04.7					
CROSS WIND	WIND SPEED	COMP R	L	KNOTS	UNIT CORR	CROSS WIND CORR	0.3		
RANGE WIND	WIND SPEED	COMP H	T	TAIL HEAD	KNOTS	MET DEF CORR	4.9 LS		
MET RANGE CORRECTION									
	KNOWN VALUES	STANDARD VALUES	VARIATIONS FROM STANDARD	UNIT CORRECTIONS	PLUS	MINUS			
RANGE WIND	016	0	016	+5.3	84.8				
AIR TEMP	101.4	100.5	0.9	-1.7		2.4			
AIR DENSITY	97.9	100.5	2.6	-3.8		8.0			
PROJ HEIGHT	30	40	10	-29		29.0			
ROTATION						15.7			
						100.5	39.4		
						29.4			
						61.1		+61	
COMPUTATION OF VE									
PROP TEMP	VE	-9.2	M/S	22.9	TOTAL RANGE CORRECTION				
	CHANGE TO MV FOR PROJ TEMP	+0.6	M/S	-17.6	MET RANGE CORRECTION	+61			
	AV	-8.6	M/S	MV UNIT CORRECTION +22.9	AV RANGE CORRECTION	+197			
					TOTAL RANGE CORRECTION	+258 +260			
MET FUZE CORRECTION									
	VE	VE	VE	VE	VE	VE	VE	VE	VE
AV	08.6	-0.046				396			
RANGE WIND	016	-0.008				128			
AIR TEMP	01.4	+0.003				004			
AIR DENSITY	02.1	+0.005				010			
PROJ HEIGHT	010	+0.066				066			
						524	MET FUZE CORRECTION	-0.4	
						080	FUZE CORRECTION	-0.0	
						444	TOTAL FUZE CORRECTION	-0.4	
FORM 4200									
AA7079				A		5/22/84			

Figure 10-39. Met to a target.

(4) The unit will fire charge 4GB, fuze time (M577), shell DPICM.

(5) The azimuth to the target is determined as follows:

Common deflection	3200
Chart deflection to target	3853
Deflection increases	653
(azimuth decreases 653)	
Azimuth of lay	6350
Change in azimuth	-653
Azimuth to target	5697

(6) Position fuze correction is 0 for the M577 fuze, since it is not similar to the M582 fuze used in registration.

(7) The completed met to a target is shown in figure 10-39.

(8) Firing data determined (for battery center) (fig 10-40) are as follows:

Time	15.8
Deflection	3851
Quadrant elevation	328

RECORD OF FIRE																																	
Observer B4H23		CALL FOR FIRE		Tgt		TGT 345 BTRY 355 VI - 10				△ FS		100/R																					
Grid:		AF/FE/S/S								/R																							
Polar: Dir		Dis		U/D		VA				20/R																							
Shift		Dir		U/R		+/-				U/D		HOB Corr																					
DLT OF BAPS W/ TRPS		1/D DPICM				Si ÷ 10				10m Si																							
FIRE ORDER		FFE CHG 4 ② AMC				Df Corr				R2		Si		-3																			
INITIAL FIRE COMMANDS		WAF MF BTRY ②		Rg 4100(16.1)		Chf Df				3353		(278)(275)																					
Sp Instr		AMC		Sh		Lot 14		Chg 4		Fz T1		Ti 15.8		Df		3851																	
MTD		G16 ② AA7019		4 T		PER		TF				in Eff		Ammo Exp		(12) DPICM																	
Tgt		Location		Priority		Firing Unit		SUBSEQUENT FIRE COMMANDS																									
Dir, MF Sh, Fz		Dev		Rg		HOB Corr		MF Sh, Chg, Fz		FS Corr		Ti		Chart Df		Df Corr ()		Df Fired		Chart Rg		HOB Corr		Si ()		EI		QE		Exp		Type	
DIR						FM		EM																									
58160																																	
2 BAPS DESTROYED EST 10CAS																		NOTE: FT 155 - AN-1 DATA															
Btry		A		DTG		5/22/84		Tgt		AA7019		Replot Grid				Replot Alt																	
DA FORM 1 OCT 78		4504		REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE										FOR USE OF THIS FORM, SEE FM 6-40; THE PROponent AGENCY IS TRADOC																			

Figure 10-40. Met to a target — DPICM mission.

Section VI

MET PLUS VELOCITY ERROR

10-20. APPLICATION OF VELOCITY ERROR

It is undesirable to register each time there is a significant change in weather. To keep range corrections current in such situations, a technique called met + VE is used. The major change in corrections is due to changes in met conditions and propellant temperature. A new met message will provide current met conditions. Velocity error is virtually constant. A total range correction is determined by adding current met range corrections to ΔV range corrections determined from the position average VE in meters per second and current corrections to MV for propellant temperature. The total range correction is applied to the GFT setting range in the same manner as a range correction determined from a registration.

10-21. MANUAL COMPUTATION OF A GFT SETTING FOR AN UNREGISTERED CHARGE

The sample problem below describes the manual computation of a GFT setting for an unregistered charge. The following situation exists: A registration has been conducted firing charge 4GB, propellant lot Y. A concurrent met has been solved. The FDC desires a GFT setting for charge 5GB, lot Y. An MVV for lot Y of -1.4 meters per second was measured for the adjusting piece during the charge 4GB registration.

a. Determine the range to a met check gage point on the charge 4GB graphical firing table. This will be used as the chart range on the met data correction sheet. The entry range will be the met check gage point range expressed to the nearest 100 meters.

b. Compute the GFT deflection correction as follows:

(1) Compute the met deflection correction by use of the met data correction sheet.

(2) Add the position deflection correction determined from the charge 4GB, lot Y, concurrent met to the newly computed met deflection correction for charge 5GB, lot Y. The sum is the total deflection correction for charge 5GB, lot Y.

Note. The position deflection correction generally accounts for errors in survey and chart construction. These errors are independent of charge in that they remain constant regardless of the charge fired. Therefore, it is valid to apply a position deflection correction determined for one charge to other charges.

(3) Subtract the drift correction corresponding to the adjusted elevation for charge 5GB from the total deflection correction. The remainder is the GFT deflection correction for charge 5GB, lot Y.

c. Compute total range correction and adjusted elevation as follows:

(1) Remember that VE is caused by factors such as chart errors, survey, tube wear, and projectile ballistic coefficient. From this statement, it can be concluded that the position VE is made up of the MVV that can be measured and the other factors that can be determined only by firing.

Note. Velocity errors caused by survey and chart errors are charge independent and, therefore, can be transferred to other charges. Muzzle velocity variations can be transferred to all charges within the same charge group and lot (chap 13).

(2) Transfer the position VE and the charge 4 MVV, add them, and then use the sum as the charge 5GB velocity error.

(3) Now add the MV correction for propellant temperature to yield the charge 5GB ΔV .

(4) Multiply ΔV by the charge 5GB MV correction factor to determine the ΔV range correction.

(5) Add the computed met range correction for charge 5GB to the ΔV range correction to determine the total range correction.

(6) Add the total range correction to the range of the met check gage point to determine the range corresponding to adjusted elevation.

(7) Set the adjusted range under the MHL of the GFT, and read the adjusted elevation for charge 5GB.

d. Compute the total fuze correction as follows:

(1) Compute the fuze correction.

(2) Add the met fuze correction to the position fuze correction determined for the charge 4GB concurrent met. The sum is the total fuze correction, which is applied to the fuze setting corresponding to the adjusted elevation to determine the adjusted fuze setting for the GFT setting for charge 5GB.



CHAPTER 11

MUZZLE VELOCITY MANAGEMENT

The muzzle velocity developed by a howitzer is the measurement of the total forces acting on it. To obtain accurate artillery fire, the firing unit must know the shooting strengths of the weapons, the propellant lots, and the projectile/ fuze combinations. Firing tables give standard muzzle velocities for standard weapons firing standard ammunition under standard conditions. However, muzzle velocities achieved in actual firing differ from the standard muzzle velocities because of variations in the manufacture of the weapon and ammunition, the wear in the weapon, nonstandard conditions, propellant lot efficiency, or a combination of these factors. The M90 velocimeter enables a firing unit to continually update MV data.

11-1. DEFINITIONS

a. Propellant Type—the type of propellant used for a particular charge; for example, M3A1, M4A2, and M206 (BCS powder model [PMOD]).

b. Powder Model—the calibrated charges within the propellant type associated with a projectile family (table 11-1).

c. Muzzle Velocity Variation—the change in MV of a weapon from the standard MV expressed in meters per second.

d. Firing Unit MVV—the average MVV for all weapons in the firing unit for a powder model.

e. Projectile Family—a group of projectiles that have exact or very similar ballistic characteristics.

Table 11-1. Example of projectile family and propellant data.

M109A1/A2/A3 PROPELLANT TYPE/PROJECTILE COMBINATIONS					
PROJECTILE FAMILY	POWDER MODEL PROPELLANTS				
	M3 SERIES	M4 SERIES	M119 SERIES	M206	M197
HIGH EXPLOSIVE	2-5	ALL	ALL	NO	NO
NUCLEAR	NO	NO	NO	ALL	ALL
ROCKET ASSISTED	2-5	ALL	ALL	NO	NO
DPICM	3-5	ALL	ALL	NO	NO
COPPERHEAD	4-5	4-7	ALL	NO	NO

NO—not valid projectile/propellant combinations.

f. Calibration—the determination of an MVV for every weapon in the firing unit. In a calibration, all weapons fire the same or an adjacent charge of a propellant and projectile lot.

g. Propellant Lot—a group of propellants made by the same manufacturer at the same location with the same ingredients. Individual propellant canisters within the same lot will develop the same MV when fired with the same projectile family.

h. Preferred Charges—the charges preferred for measuring muzzle velocities for each propellant type. These charges produce consistent, predictable muzzle velocities. The MVVs they produce will not vary more than ± 1.5 meters per second. Therefore, the MVV determined for one charge of the propellant type will be similar (within ± 1.5 meters per second) to another charge of the same propellant type and lot. Preferred charges are identified in table 11-2.

Table 11-2. Preferred charges.

PROPELLANT TYPE	PREFERRED CHARGES
M67	2, 5, 7
M176	7
M3A1	3, 4, 5
M4A2	5, 6, 7
M119 SERIES	ALL
M197	ALL
M206	ALL
M207	ALL
M1	3, 4, 5
M2	5, 6, 7
M80	ALL
M188 SERIES	ALL

i. Inferred Calibration—the determination of MVV data for all firing unit weapons by mathematical procedures.

j. Readout Average—the average M90 readout of a group of projectiles.

k. Calibrated Muzzle Velocity—the MV of a group of projectiles when corrected to standard conditions by applying corrections for propellant temperature and projectile weight to the measured muzzle velocity.

l. Measured Muzzle Velocity—calibrated MV from the first-lot calibration entered on the muzzle velocity record.

11-2. CALIBRATION

a. Muzzle Velocity Data. The M90 velocimeter makes current MV data available to the FDC for use with concurrent/subsequent mets and for position corrections. Use of the M90 velocimeter and the proper management and recording of data are critical in the use of these data. The following discussion outlines MVV management procedures.

b. Muzzle Velocity Logbook.

(1) **Sectioning the logbook.** The FDO sections the major portions of his logbook by the projectile families (fig 11-1).

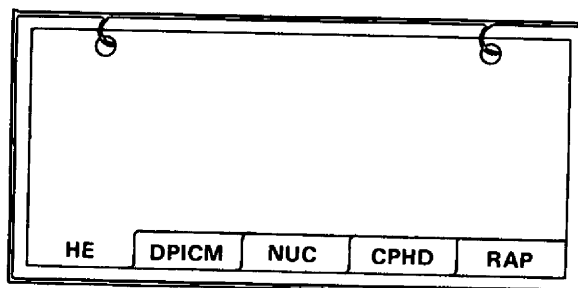


Figure 11-1. Muzzle velocity logbook sectioned by projectile family.

(2) **Tabbing the logbook.** Each section (projectile family) of the MV logbook is tabbed with all possible powder models (fig 11-2). After the MV logbook has been sectioned and tabbed, it will be ready for entry of data.

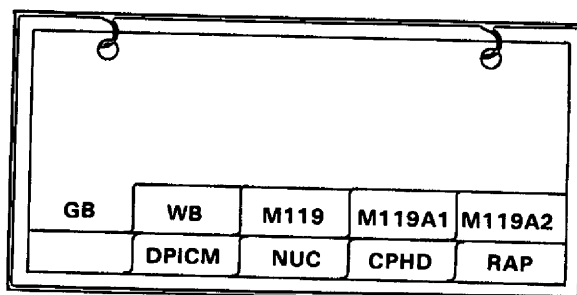


Figure 11-2. Muzzle velocity logbook tabbed by powder model.

c. Calibration.

(1) **Determination of data.** The howitzer section mounts the M90 velocimeter. The executive officer directs the velocimeter operator to record all administrative data on DA Form 4982-1-R (M90 Velocimeter Work Sheet) (fig 11-3 and app J). The M90 readout

values are recorded on the bottom portion of the form. Normally, data from six usable rounds are used to maximize accuracy. These six rounds can be from any fire mission received by the battery. Specially conducted calibration missions or firing sessions are not required. Fewer than six rounds can be fired in a calibration, or fewer than six rounds may

M90 VELOCIMETER WORK SHEET						
For use of this form, see FM 6-40; the proponent agency is TRADOC.						
CHARGE GROUP <i>M4A2</i>	DATE/TIME <i>30 SEP 83, 0920</i>		PROJECTILE/FAMILY <i>HE</i>			
PROJECTILE MODEL <i>HE M107</i>	POWDER LOT NUMBER <i>WA-23-5761</i>		PROJECTILE WEIGHT <i>4 lb</i>			
ITEMS <i>a</i>	GUN 1 CHARGE <i>b</i>	GUN 2 CHARGE <i>c</i>	GUN 3 CHARGE <i>d</i>	GUN 4 CHARGE <i>e</i>	GUN 5 CHARGE <i>f</i>	GUN 6 CHARGE <i>g</i>
1. WEAPON BUMPER NUMBER	<i>A-22</i>	<i>A-24</i>	<i>A-26</i>	<i>A-28</i>	<i>A-30</i>	<i>A-32</i>
2. WEAPON TUBE NUMBER	<i>1122</i>	<i>2233</i>	<i>3344</i>	<i>4455</i>	<i>5566</i>	<i>6677</i>
3. STARTING POWDER TEMPERATURE		<i>70</i>				
4. ENDING POWDER TEMPERATURE		<i>70</i>				
5. AVERAGE POWDER TEMPERATURE		<i>70</i>				
M90 VELOCIMETER READOUT						
ROUND 1		<i>560.1</i>				
ROUND 2		<i>559.2</i>				
ROUND 3		<i>559.1</i>				
ROUND 4		<i>552.7E</i>				
ROUND 5		<i>559.2</i>				
ROUND 6		<i>560.3</i>				
ROUND 7		<i>571.5E</i>				
ROUND 8		<i>559.2</i>				
READOUT AVERAGE		<i>559.5</i>				
6. MUZZLE VELOCITY CORRECTION FOR NONSTANDARD CONDITIONS		<i>0.0</i>				
7. CALIBRATED MUZZLE VELOCITY		<i>559.5</i>				
8. NUMBER OF WARMUP ROUNDS FIRED		<i>2</i>				
REMARKS						

DA FORM 4982-1-R SEP 84 EDITION OF MAY 1981 IS OBSOLETE

Figure 11-3. Determining M90 readout values on DA Form 4982-1-R.

be determined to be usable rounds. In these situations, the calibration validity is reduced in the same manner the validity of a registration is reduced when fewer than the normal amount of rounds are fired. Refer to table 12-1 for validity information and the effect of reduced rounds on the calibration data. Powder temperature differences between rounds decrease the validity of the calibration. To reduce powder temperature changes from round to round, use good propellant handling and storing procedures in the firing battery, and fire all rounds to be measured for a calibration within a 20-minute time period. Follow these procedures for the calibration of all weapons. When the administrative data and the M90 velocimeter readout data are completed on the form for all guns, give the form to the fire direction center.

(2) **Determination of M90 readout average.** The FDO inspects the readout values for all rounds and deletes any invalid

readout values (errors). The FDC then determines the readout average for the usable rounds by adding all usable readout values and dividing the sum by the number of usable readouts. The readout average is the actual speed, in meters per second, of the average of the usable projectiles as they left the tube. This value includes the effects of nonstandard propellant temperature and projectile weight.

(3) **Correction to standard.** The M90 velocimeter readout is not used in its present form, because it contains the effects of projectile weight and propellant temperature on the muzzle velocity. The MVV determined from the readout average can be used only after it is corrected to standard projectile weight and standard propellant temperature. The corrections for projectile weight and propellant temperature are applied by extracting the value for the MV correction from the appropriate table in MVCT-M90-1 correction tables (fig 11-4) and applying this

CHARGE 4G	HOWITZER, 155MM, M109A1 AND M198							MVCT M90-1 PROJ, HE, M107
CORRECTIONS TO MUZZLE VELOCITY IN METERS PER SECOND TO COMPENSATE FOR DIFFERENCES IN PROJECTILE WEIGHT AND PROPELLANT TEMPERATURE								
TEMPERATURE OF PROPELLANT DEGREES F	PROJECTILE WEIGHT IN SQUARES *							TEMPERATURE OF PROPELLANT DEGREES C
	1 SQ	2 SQ	3 SQ	4 SQ	5 SQ	6 SQ	7 SQ	
-40	1.2	2.9	4.6	6.3	8.0	9.7	11.4	-40.0
-30	.6	2.3	4.0	5.7	7.4	9.1	10.9	-34.4
-20	.1	1.8	3.5	5.2	6.9	8.6	10.3	-28.9
-10	-.5	1.2	2.9	4.6	6.3	8.0	9.7	-23.3
0	-1.1	.6	2.3	4.0	5.7	7.4	9.2	-17.8
10	-1.7	.0	1.7	3.4	5.2	6.9	8.6	-12.2
20	-2.3	-.6	1.2	2.9	4.6	6.3	8.0	-6.7
30	-2.9	-1.1	.6	2.3	4.0	5.7	7.5	-1.1
40	-3.4	-1.7	.0	1.7	3.4	5.2	6.9	4.4
50	-4.0	-2.3	-.6	1.1	2.9	4.6	6.3	10.0
60	-4.6	-2.9	-1.2	.6	2.3	4.0	5.8	15.6
70	-5.2	-3.5	-1.7	0.0	1.7	3.5	5.2	21.1
80	-5.8	-4.0	-2.3	-.6	1.2	2.9	4.6	26.7
90	-6.4	-4.6	-2.9	-1.1	.6	2.3	4.1	32.2
100	-7.0	-5.2	-3.5	-1.7	.0	1.8	3.5	37.8
110	-7.5	-5.8	-4.0	-2.3	-.6	1.2	2.9	43.3
120	-8.1	-6.4	-4.6	-2.9	-1.1	.6	2.4	48.9
130	-8.7	-7.0	-5.2	-3.4	-1.7	.1	1.8	54.4

Figure 11-4. Extract of MVCT-M90-1 tables.

value to the readout average. The correction tables contain data to reflect what the readout average would have been if the reading had been determined with a 4-square-weight projectile and a propellant temperature of 70° F. Enter MVCT-M90-1 with the appropriate weapon system and projectile family. Locate the page containing the table for the same charge fired in the calibration. Enter the table with the temperature of the propellant at the time of the calibration and the weight of the projectile fired in the calibration. Interpolate the value to correct the readout average to standard, and apply that value to the readout average.

EXAMPLE:**Given:**

Propellant temperature: +46° F

Projectile weight: 3 squares

Readout average: 559.5 m/s

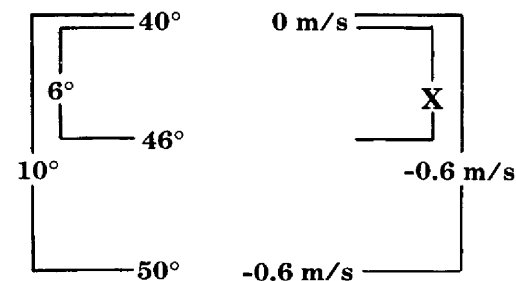
MVCT-M90-1 extract (fig 11-5)

Determine the calibrated muzzle velocity.

1. Enter MVCT-M90-1 table using propellant temperature to nearest 1° F and projectile weight to nearest listed value as entry arguments. (Interpolation of data from tables will be required.)

2. The value extracted from the table is the correction factor which, when applied to the readout average, corrects the data to reflect the standard propellant temperature (70° F) and the standard projectile weight (4 squares). Since interpolation will be required, extract the range of values that contains the correction factor.

From table:



$$6/10 = X/-0.6$$

$$10X = -3.6$$

$$X = -0.36 \approx -0.4 \text{ m/s}$$

$$0 \text{ m/s} + (-0.4) \text{ m/s} = -0.4 \text{ m/s}$$

3. Determine the calibrated muzzle velocity by adding the MVCT-M90-1 correction factor determined in step 2 to the readout average.

Readout average	317.1 m/s
MVCT-M90-1 corr factor	+ (-0.4) m/s
Calibrated muzzle velocity	316.7 m/s

(4) Use of muzzle velocity record form. DA Form 4982-R (Muzzle Velocity Record) (fig 11-5 and app J) is the record of a calibration or a partial calibration. The top portion of the form (FIRST LOT CALIBRATION) is used to determine the weapon MVV and MV for a specific charge. The bottom portion of the form (SECOND LOT CALIBRATION/INFERENCE) is used to infer MVV data for a second lot of propellant/ammunition.

(5) Determination of first-lot piece MVV. From the TFT, extract the standard MV for the charge fired in the calibration. Compare the calibrated MV to the standard MV to yield the MVV for each piece.

(6) Determination of the weapon muzzle velocity. Apply the piece MVV to the standard MV to determine the weapon MV for that powder model. Now enter the muzzle velocity record in the muzzle velocity logbook in the appropriate shell family and powder model for future reference. The appropriate data are entered in the computer system available to the battery and are made available to the executive officer for entry on DA Form 2408-4 (Weapon Record Data). If a computer system is not available, use DA Form 4758 (Section Chief's Card, Computation Work Sheet).

(7) Use of MVV. To determine position VE, subtract the MVV from the VE determined in a concurrent met. A position VE can be used in a subsequent met to determine the VE by adding the position VE to any MVV from any powder model (POS VE + MVV = VE). Muzzle velocity variation is also used to determine a comparative MVV with deliberate or hasty position corrections.

MUZZLE VELOCITY RECORD				DATE		POWDER GROUP	
For use of this form, see FM 6-40; the proponent agency is TRADOC.				22 MAY 84		M4A2	
FIRST LOT CALIBRATION							
SHELL/FAMILY	FIRST POWDER LOT NUMBER	GUN NUMBER/CHARGE FIRED					
HE	WA-23-5761						
ITEMS	1/	2/	3/	4/	5/	6/	
1. WEAPON BUMPER NUMBER	A-22	A-24	A-26	A-28	A-30	A-32	
2. WEAPON TUBE NUMBER	1122	2233	3344	4455	5566	6677	
3. FIRST LOT CHARGE STANDARD MUZZLE VELOCITY	565.4	565.4	565.4	565.4	565.4	565.4	
4. CALIBRATED MUZZLE VELOCITY	562.9	562.8	563.9	563.2	563.0	565.3	
5. FIRST LOT PIECE MUZZLE VELOCITY VARIATION	-2.5	-2.6	-1.5	-2.2	-2.4	-0.1	
SECOND LOT CALIBRATION/INFERENCE							
SHELL/FAMILY	POWDER GROUP	GUN NUMBER/CHARGE FIRED					
HE	M4A2	22 MAY 84					
ITEMS	1/	2/	3/	4/	5/	6/	
6. SECOND LOT CHARGE STANDARD MUZZLE VELOCITY				565.4			
7. SECOND LOT CALIBRATED MUZZLE VELOCITY				562.5			
8. FIRST LOT PIECE MUZZLE VELOCITY VARIATION (5)				-2.2			
9. CHANGE IN MUZZLE VELOCITY VARIATION				-0.7			
10. FIRST LOT PIECE MUZZLE VELOCITY VARIATION (5)				-2.2			
11. CHANGE IN MUZZLE VELOCITY VARIATION (9)				-0.7			
12. SECOND LOT INFERRED FIRING UNIT MUZZLE VELOCITY VARIATION				564.7			
13. SECOND LOT STANDARD MUZZLE VELOCITY				564.4			
14. SECOND LOT CALIBRATED MUZZLE VELOCITY							
15. SECOND LOT PIECE MUZZLE VELOCITY VARIATION							

DA FORM 4982-R SEP 84

EDITION OF MAY 1981 IS OBSOLETE

Figure 11-5. Muzzle velocity record.

11-3. DETERMINATION OF MUZZLE VELOCITY FOR SUBSEQUENT LOTS

During the course of firing or during tactical operations, subsequent lots of propellant will be delivered to a firing unit. Because of operational constraints, calibration of those subsequent lots may be difficult or impossible to conduct before the MVV data are required. In these cases, an inferred calibration can be performed by use of the following procedures:

a. Determination of Calibrated Muzzle Velocity. An adjusting piece is assigned to determine the calibrated MV of the second lot by firing six rounds of the subsequent lot. The M90 velocimeter readout values are averaged, and correction values from MVCT-M90-1 are applied.

b. Determination of Subsequent Lot MVV. Using the muzzle velocity record, complete the administrative information for the subsequent lot inference. Enter the subsequent lot calibrated muzzle velocity (determined from the firings) on the form, and determine the muzzle velocity variation.

c. Determination of the Change in MVV. Compare the calibrated lot piece MV to the subsequent lot piece MV to determine the change in MVV between the two lots. The calibrated lot and the subsequent lot do not

need M90 readout values determined with the same charge as long as both charges are preferred charges.

d. Determination of Subsequent Lot Inferred Piece MVV. Determine the subsequent lot inferred piece MVV by applying the change in MVV to the calibrated lot piece MVV. This procedure is possible, since calibration is primarily a measurement of propellant efficiency. The observed performance of a calibrated/subsequent lot may be used as an indicator of the subsequent lot in the noncalibrated weapons. Determine a change in MVV by comparing the subsequent lot MVV with the previous lot MVV for the same weapon. This change in MVV shows a difference in the efficiency of the individual pieces in the use of the two propellants. It is assumed that the same change in MVV is constant among all weapons in the unit. Apply the change in MVV to the previously calibrated lot MVV for each piece in order to infer the subsequent lot noncalibrated MVV for each weapon.

11-4. CALIBRATION OF SUBSEQUENT LOTS

If time or the tactical situation permits, the subsequent lot of ammunition should be calibrated. The lower portion of the muzzle velocity record is provided for recording the calibration and for computing muzzle velocity variations (fig 11-5).



Chapter 12

REGISTRATIONS AND APPLICATION OF REGISTRATION CORRECTIONS

If all conditions of materiel, position, and weather are standard, firing a cannon at a particular elevation will cause the projectile to travel the range shown in the firing table corresponding to that elevation. See figure 10-1 for a list of standard conditions. Similarly, if the proper deflection is set on the weapon, the projectile will burst on the gun-target line. However, standard conditions of materiel, position, and weather do not exist simultaneously. Thus, the

projectile will rarely hit the target when fired with standard data for the range and deflection.

Inaccurate surveys, inaccurate firing charts, and nonstandard conditions of materiel, position, and the atmosphere will contribute errors. The number of meters short or over, left or right of the target is the combined effect of these errors. The magnitude of the cumulative errors and the corrections for those errors can be determined by registration.

SECTION I CHARACTERISTICS

12-1. TYPES OF REGISTRATIONS

The two types of registrations are precision and HB/MPI. In the two categories, there are alternative methods of registering that may be more suitable to the current tactical situation.

a. Precision Registration. The precision registration is a technique used for determining, by adjustment, the firing data that will place the MPI of a group of rounds on a point of known location. This point is called a registration point.

b. HB/MPI Registration. The HB and MPI registrations determine the mean burst location (MBL) of a group of rounds fired with a single set of firing data.

c. Alternate Registration Types.

(1) Radar-observed registration. The radar registration is a form of the HB/MPI registration and is thoroughly discussed in the latter part of this chapter.

(2) Abbreviated registration. Any registration that is conducted by using fewer usable rounds than recommended by the precision HB/MPI techniques is an abbreviated registration. The use of fewer rounds results in the degradation of registration correction data. However, the use of fewer rounds to determine the MBL or the use of a larger "acceptance box" (for example, 2 PEs rather than 1 PE from the MPI) is acceptable if the decreased accuracy is acceptable to the commander and if it is for the accomplishment of the mission.

(a) *Abbreviated HB/MPI registration.* An abbreviated HB/MPI registration is conducted exactly like an HB/MPI registration, except that as few as one, two, or three rounds are actually fired.

(b) *Met + VE and check round(s).* This form of abbreviated registration requires the solution of a subsequent met to an accurately located target and determines adjusted data by adjusting a round(s) fired by use of the met + VE firing data. Corrections are determined on the basis of observer refinement.

(c) *Abbreviated G/VLLD registration.* The abbreviated G/VLLD registration determines adjusted data by comparing the target location with the location of the lased round.

(d) *Adjust fire missions.* Any adjust fire mission conducted on an accurately located target or by an accurately located observer by use of a G/VLLD can be used to improve firing accuracy by determining registration corrections on the basis of the observer adjustments. In this case, refinement data must be sent by the observer. The validity of the GFT setting is directly proportional to the accuracy of the target location.

Note. Use of the G/VLLD enables an observer to accurately locate a target to registration-required accuracy.

(3) **Offset registration.** A platoon or offset position as much as 1,000 to 2,000 meters away from the battery center can be used to conduct a registration. The GFT setting determined from the offset position is assumed to be valid for the primary position if common survey and common direction

exist between the two positions. A registration from a flank platoon may reduce the vulnerability of the battery.

(4) To the rear registration.

(a) Registering to the rear (or at some azimuth significantly different from the primary azimuth of fire) results in a GFT setting that does not include the primary azimuth of fire within its deflection transfer limits.

(b) To derive a GFT setting for the primary azimuth of lay, apply eight-direction met techniques as follows:

- Determine position corrections by working a concurrent met for the registration azimuth.
- Using subsequent met techniques, determine total corrections (in the direction of the azimuth of lay) by reworking the met. See chapter 10 for a discussion of the eight-direction met technique.

12-2. ASSURANCE TABLES

A registration conducted with fewer rounds than recommended will degrade the accuracy of the determined corrections. Accuracy decreases as fewer rounds are used. Table 12-1 lists the percentage of probability that the mean location of a particular number of rounds is within 1 or 2 probable errors in range of the actual mean point of impact. As more rounds are fired, the MPI is more accurately located. If the tactical situation dictates that registrations be abbreviated, the assurance received from a full registration may have to be reduced.

Table 12-1. Assurance of registration validity.

NUMBER OF ROUNDS FIRED	1	2	3	4	5	6
WITHIN 1 PROBABLE ERROR	50%	66%	76%	82%	87%	90%
WITHIN 2 PROBABLE ERRORS	82%	94%	98%	99%	99%	99%

12-3. WHEN TO CONDUCT REGISTRATIONS

a. A mission conducted only for the purpose of registering does not cause any damage to the enemy. It does, however, expose the firing unit to enemy target acquisition devices. In addition, missions conducted solely for the purpose of registering require additional ammunition and time. Therefore, when possible, registration missions should be integrated into other missions, especially when the observer is equipped with a G/VLLD (app K).

b. Computer-derived GFT settings or met + VE GFT settings should be used when accurate MVVs, met data, and survey are available. The amount of corrections necessary to adjust onto a target will be minimal and can most likely be accounted for

in the observer's first adjustment. Firing two check rounds for an inferred GFT setting can be an abbreviated registration. Any refinement sent by the observer should be used to adjust the GFT setting and computer residuals.

c. Registrations (fig 12-1) are not necessary if you—

- (1) Have confidence in weapon location and directional control.
- (2) Have confidence in met.
- (3) Have confidence in muzzle velocity.
- (4) Have a valid derived GFT setting.

d. The accuracy gained by conducting a mission solely for registering should be weighed carefully against the vulnerability to enemy detection and against the expenditure of ammunition and time.

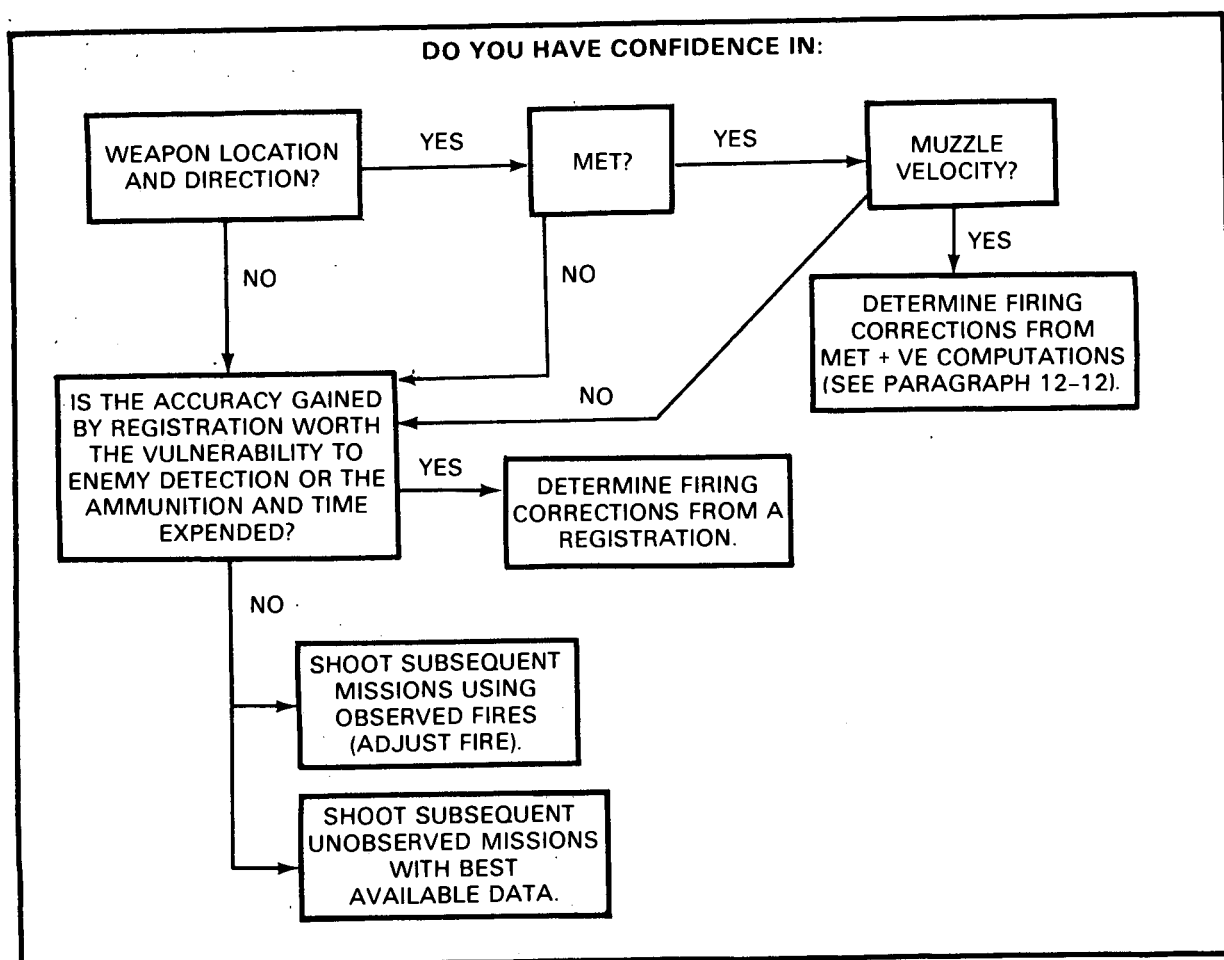


Figure 12-1. Registrations.

Section II

PRECISION REGISTRATIONS

12-4. DEFINITION AND OBJECTIVE

a. Definition. Precision registration is a technique that requires an observer to adjust a group of rounds fired from the same gun so that their mean point of impact occurs at a point of known location. The point of known location is called a registration point. Registration points should be small, hard targets that are easily identified, immobile, accurately located, and not likely to be completely destroyed if hit. Registration points should be surveyed points, and their locations should be provided by a target area survey of the intended zone of operations. If a target area survey has not been conducted, registration points can be selected and located by the forward observer.

b. Objective. The observer's objective in a precision registration is to obtain spottings of two **OVERS** and two **SHORTS** along the observer-target line from rounds fired with the same data or from rounds fired with data 25 meters apart (50 meters apart when **PER** is greater than or equal to 25 meters). This normally requires the spottings of four separate rounds. However, a **TARGET HIT** or **RANGE CORRECT** will be spotted by the observer as both an **OVER** and a **SHORT**. The objective of the time portion of the registration is to correct the mean height of burst of four rounds fired with the same data to 20 meters above the registration point. The FDC's objective in a precision registration is to determine corrections to firing data on the basis of the observer's corrections.

12-5. INITIATION

a. The decision to register is based on the considerations in section I. After the decision to register has been made, the FDO announces a fire order. As in all fire orders, the FDO tells the FDC, clearly and concisely, how to conduct the registration according to unit SOP; for example, **PRECISION**

REGISTRATION, NUMBER 4, 1 ROUND, LOT XY, CHARGE 4, QUICK AND TIME. In this example, **PRECISION REGISTRATION** tells the FDC the type of mission to be fired. **QUICK AND TIME** tells the FDC the correction to be determined for both quick and time fuzes. The registering piece is selected as the piece closest to the GBC and by its average shooting strength; in this case, number 4 firing one round. If there is more than one registration point available or if a second lot is to be registered, that information is also specified in the fire order; for example, **PRECISION REGISTRATION, REGISTRATION NUMBER 4, 1 ROUND, CHARGE 4, QUICK AND TIME, REGISTRATION POINT 1** or **PRECISION REGISTRATION NUMBER 4, 1 ROUND, LOT XY, CHARGE 4, QUICK AND TIME, LOTS X AND W.**

b. When the RATELO hears the fire order, he will send a message to observer to alert the observer. **C8T16, THIS IS C8T23, REGISTER ON REGISTRATION POINT 1, QUICK AND TIME. OVER.** The registration point is always specified to the observer. The range probable error is also announced in the message to observer when it is greater than 25 meters. See FM 6-30.

c. Digital transmission procedures are discussed in the DMD and BCS operator's manuals.

12-6. IMPACT PORTION OF THE REGISTRATION

a. Fire direction procedures for the impact portion of the registration are identical to those for any adjust fire mission. All corrections are entered into the computer, entered on the calculator, or plotted on the firing chart. Data are computed and transmitted to the adjusting piece.

b. The firing data corresponding to standard conditions (chart data) when compared to the firing data with observer

refinement applied to it (adjusted data) result in registration corrections. The adjusted data account for the sum of the nonstandard conditions.

c. Examples of the determination of manual firing data for the impact portion of a registration appear in figure 12-2. If a previously fired or derived GFT setting is available, the FDO must decide the validity of that GFT setting and, on the basis of that decision, decide whether to use that GFT setting for the registration. In figure 12-2, the FDO decided the current GFT setting was invalid.

RECORD OF FIRE																	
CALL FOR FIRE										REG PT 1 377 DFT				Δ PS			
Observer <u>C 8 T 16</u> AF/FFE/IS/S _____ Tgt _____										BTRY <u>355 LG</u>				100/R <u>20</u>			
Grid: _____										VI <u>+22 DFT L6</u>				/R _____			
Polar: Dir _____ Dis _____ U/D _____ VA _____														20/R <u>4</u>			
Shift <u>DIR 0220</u> Dir _____ L/R _____ +/- _____ U/D _____										$\div$ Si $\div$ 10				10m Si _____			
FIRE ORDER <u>PREC REG, REG PT 1 #4 LOT XY CHG 4</u>										Df Corr <u>L6</u>				MOB Corr _____			
INITIAL FIRE COMMANDS FM MF <u>#4 ADJ</u> Rg <u>5070</u>										Cht Df <u>3304</u>				Si <u>+5</u>			
Sp Instr _____ Sh _____ Lot XY _____ Chg <u>4</u> Fz _____ Ti _____										Df <u>3310</u>				EI <u>310</u>			
MTO <u>REG, ON REG PT 1</u>										<u>41 (380)</u>				Pfr <u>(225)</u> TF _____			
										in Eff _____				Ammo Exp <u>①</u>			
Tgt	Location	Priority	Firing Unit	SUBSEQUENT FIRE COMMANDS													
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (LG)	Df Fired	Chart Rg	HOB Corr	Si (+5)	EI	QE	Exp	Type	
	L40	+200					3301	L6	3307	5280		+5	327	332	②		
		-100					3307	L6	3313	5180		+5	319	324	③		
		+50					3305	L6	3311	5240		+5	324	329	④		
②		+25		②			3304	L6	3310	5260		+5	325	330	⑤		
①		-25		①			3305	L6	3311	5240		+5	324	329	⑦		
	R10	+10	REC				3303	L6	3309	5230			324				
AS REG PT 1				EM				EM									
FDO DECIDES CURRENT GFT SETTING IS INVALID																	
Btry <u>A</u>		DTG _____		Tgt <u>MS 3200</u>		Replot Grid _____		Replot Alt _____									
DA FORM 4504 1 OCT 78		REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE										FOR USE OF THIS FORM, SEE FM 6-40; THE PROponent AGENCY IS TRADOC					

Figure 12-2. Impact registration.

12-7. REGISTERING PIECE DISPLACEMENT

a. When the registering piece is not over battery center, the chart range measured from battery center is not the range actually achieved. With the registering piece behind the battery center, the achieved range is greater than the chart range. The difference between chart range and achieved range must be taken into account when using the results of the registration as the basis for a GFT setting.

b. When the registering piece is left or right of battery center, the correction deflection (circled on the record of fire) is not the adjusted deflection.

c. Assume the registration used in previous paragraphs was conducted and the registering piece was not over battery center. The steps to account for piece displacement are shown on section I of DA Form 4757 (fig 12-3).

(1) Determine the achieved range.

(a) Enter the chart range in [1] of the registration computation section.

(b) Enter the piece displacement (B20) in [2].

(c) Add or subtract (as indicated by the displacement forward or back) the piece

displacement to the initial chart range. The result is the achieved range (the range that the projectile actually traveled). Enter the result in [3].

(d) Now use the achieved range instead of the initial chart range in determining registration corrections.

(2) Determine the adjusted deflection.

(a) Enter the correct deflection (circled on the record of fire) in [7].

(b) Enter the lateral displacement (L130) in [4], and use the previously computed achieved range to convert the displacement in meters to a correction in mils.

(c) Using the GST (C- and D-scales and M-gage point), divide the lateral displacement by the achieved range in thousands of meters and record the result in [6] ($130 \text{ meters} \div 5.09 = L26$).

(d) Add the corrected deflection ([7]) to the piece displacement correction ([8]). The result is the adjusted deflection ([9]).

12-8. TIME PORTION OF THE REGISTRATION

a. The time portion of the registration can begin when the observer requests fuze time (fig 12-4).

SECTION I. REGISTRATION COMPUTATION									
ACHIEVED RANGE					DEFLECTION CORRECTION				
1	CHART RANGE	5070 (10 METERS)			7	CORRECTED DEFLECTION (REGISTRATION)	3309 (1 MIL)		
2	REGISTERING PIECE DISPLACEMENT (F B-)	+20 (10 METERS)			8	REGISTERING PIECE DISPLACEMENT CORRECTION (5) (L R)	+26 (1 MIL)		
3	ACHIEVED RANGE (1 + 2)	5090 (10 METERS)			9	ADJUSTED DEFLECTION (7 + 8)	3335 (1 MIL)		
REGISTERING PIECE DISPLACEMENT CORRECTION					10	CHART DEFLECTION	3304 (1 MIL)		
4	LATERAL DISPLACEMENT (L R)	L130 (5 METERS)			11	TOTAL DEFLECTION CORRECTION (9 - 10) (L R)	L31 (1 MIL)		
5	ACHIEVED RANGE (3)	5090 (10 METERS)			12	DRIFT CORRECTION (1 - ADJUSTED ELEVATION) (L)	L7 (1 MIL)		
6	REGISTERING PIECE DISPLACEMENT CORRECTION (4 - 5) (L R)	L26 (1 MIL)			13	GRAPHICAL FIRING TABLE (GFT) DEFLECTION CORRECTION (11 - 12)	L24 (1 MIL)		
GFT SETTING (MANUAL METHOD)									
14	GFT	CHARGE	LOT	RANGE	ELEVATION	TIME	DEFLECTION CORRECTION		
15	A	4	XY	5090	324		TOTAL	GFT	
							L31	L24	

Figure 12-3. Registering piece displacement.

PREC REG Q&TI															RECORD OF FIRE																			
Observer <u>BGH23</u>										CALL FOR FIRE																								
Grid: _____										REG PT2 <u>376 GFT L24</u>																								
Polar: Dir _____ Dis _____ U/D _____ VA _____										BTRY <u>353 DFT L7</u>																								
Shift: _____ Dir _____ L/R _____ +/- _____ U/D _____										VI <u>+21 L31</u>																								
<u>DIR 0800</u>										SI $\div 10$ 10m SI																								
FIRE ORDER <u>PREC REG, REG PT 2, #2, LOT XY, CHG 4, Q&TI</u>															Df Corr <u>L31</u>					SI <u>+5</u>														
INITIAL FIRE COMMANDS ☒ FM ☐ MF <u>#2 ADJ</u>															Rg <u>5360</u>					Chf Df <u>2755</u>					EI <u>346</u>									
Sp Instr _____															Sh _____ Lot _____ Chg _____ Fz _____ TI _____					Df _____					QE _____									
MVO <u>REG ON REG PT2 Q&TI</u>															<u>4</u> T					Pgr (<u><25</u>) TF					<u>Q&TI</u> in Eff					Ammo Exp <u>(1)</u>				
Tgt		Location	Priority	Firing Unit	SUBSEQUENT FIRE COMMANDS																													
Dir, MF Sh, Fz	Dev	Rg	NOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (L-S)	Df Fired	Chart Rg	NOB Corr	Si (+-)	EI	QE	Exp	Type																		
	<u>R200</u>	<u>-200</u>					<u>2735</u>	<u>L31</u>	<u>2766</u>	<u>5100</u>		<u>+5</u>	<u>324</u>	<u>329</u>	<u>(2)</u>																			
		<u>+100</u>					<u>2729</u>	<u>L31</u>	<u>2759</u>	<u>5190</u>		<u>+5</u>	<u>332</u>	<u>337</u>	<u>(3)</u>																			
		<u>+50</u>					<u>2723</u>	<u>L31</u>	<u>2754</u>	<u>5240</u>		<u>+5</u>	<u>336</u>	<u>341</u>	<u>(4)</u>																			
<u>(2)</u>		<u>-25</u>		<u>(3)</u>			<u>2726</u>	<u>L31</u>	<u>2757</u>	<u>5220</u>		<u>+5</u>	<u>334</u>	<u>339</u>	<u>(6)</u>																			
<u>(1)</u>		<u>+25</u>		<u>(1)</u>			<u>2723</u>	<u>L31</u>	<u>2754</u>	<u>5240</u>		<u>+5</u>	<u>336</u>	<u>341</u>	<u>(3)</u>	<u>Q</u>																		
	<u>L10</u>	<u>-10</u>	<u>REC</u>				<u>2729</u>	<u>L31</u>	<u>2759</u>	<u>5230</u>		<u>+5</u>	<u>(335)</u>																					
<u>AS REG</u>	<u>PT2 TI</u>		<u>RPT</u>	<u>F2 TI</u>		<u>19.2</u>			<u>2759</u>		<u>+4</u>	<u>+9</u>	<u>335</u>	<u>344</u>	<u>(1)</u>																			
<u>(3) RPT</u>			<u>U40</u>		<u>-0.4</u>	<u>18.9</u>			<u>(2759)</u>					<u>344</u>	<u>(2)</u>																			
				<u>(5)</u>		<u>(18.9)</u>			<u>(2759)</u>					<u>344</u>	<u>(5)</u>	<u>TI</u>																		
<u>REC AS</u>	<u>TI REG</u>		<u>2EM</u>	<u>EM</u>	<u>+0.1</u>	<u>(18.9)</u>																												
GFT A: CHG 4, LOT XY, RG 5090, EL 324 GFT DF CORR L24 (USED FOR THIS REGISTRATION)																																		
Btry <u>A</u>		DTG <u>5/22/94</u>		Tgt <u>REG PT 2</u>		Replot Grid		Replot Alt																										
DA FORM 4504 1 OCT 78		REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE										FOR USE OF THIS FORM, SEE FM 6-40 THE PROponent AGENCY IS TRADOC																						
SECTION I. REGISTRATION COMPUTATION																																		
ACHIEVED RANGE							DEFLECTION CORRECTION																											
1	CHART RANGE		<u>5360</u> (10 METERS)				7	CORRECTED DEFLECTION (REGISTRATION)		<u>2759</u> (1 MIL)																								
2	REGISTERING PIECE DISPLACEMENT (F B-)		<u>-220</u> (10 METERS)				8	REGISTERING PIECE DISPLACEMENT CORRECTION (6) (L-R)		<u>-2</u> (1 MIL)																								
3	ACHIEVED RANGE (1) + (2)		<u>5140</u> (10 METERS)				9	ADJUSTED DEFLECTION (7) + (6)		<u>2757</u> (1 MIL)																								
REGISTERING PIECE DISPLACEMENT CORRECTION							10	CHART DEFLECTION		<u>2755</u> (1 MIL)																								
4	LATERAL DISPLACEMENT (L R)		<u>R 10</u> (5 METERS)				11	TOTAL DEFLECTION CORRECTION (9) + (10) (L-R)		<u>12</u> (1 MIL)																								
5	ACHIEVED RANGE (3)		<u>5140</u> (10 METERS)				12	DRIFT CORRECTION (1) - ADJUSTED ELEVATION (L)		<u>17</u> (1 MIL)																								
6	REGISTERING PIECE DISPLACEMENT CORRECTION (4) - (5) (L-R)		<u>R 2</u> (1 MIL)				13	GRAPHICAL FIRING TABLE (GFT) DEFLECTION CORRECTION (11) (12)		<u>R 5</u> (1 MIL)																								
GFT SETTING (MANUAL METHOD)												DEFLECTION CORRECTION																						
14	GFT	<u>A</u>	CHARGE	<u>4</u>	LOT	<u>XY</u>	RANGE	<u>5140</u>	ELEVATION	<u>335</u>	TIME	<u>18.9</u>	TOTAL	GFT																				
15	GFT		CHARGE		LOT		RANGE		ELEVATION		TIME		<u>12</u>	<u>R 5</u>																				
16	GFT								ELEVATION																									

Figure 12-4. Precision registration—quick and time.

b. The observer's refinement corrections move the mean point of impact to the registration point and provide an adjusted deflection and elevation. The fuze setting for the first round fired in the time portion of the registration corresponds to the adjusted elevation determined in the impact portion of the registration.

Note. If a GFT setting was used during the impact portion of the registration, it will be discarded before the time portion begins. When firing the registration, determine the first fuze setting for the time portion by placing the MHL over the adjusted elevation from the impact portion of the registration and reading time from the time scale. Any known position fuze correction can be applied to the time determined from the MHL. Determine ΔFS at this fuze setting.

c. When firing manually, add 20/R to the ground site to determine total site. Add the total site to the adjusted elevation to determine quadrant to fire for the time portion of the registration.

d. Determine the adjusted time by applying the observer's height-of-burst refinement to the final time. The adjusted time setting is not fired.

12-9. MULTILOT PRECISION REGISTRATIONS

Multilot precision registrations (fig 12-5), are conducted in the same manner as single-lot registrations. The fuze correction remains the same for all propellant lots. Each registered lot has a separate impact registration conducted. The adjusted time for the subsequent lot GFT setting is determined by adding the fuze correction from the first lot to the fuze setting corresponding to the subsequent lot adjusted elevation. The adjusted deflection determined upon completion of the impact portion of the first lot will be used as the adjusted deflection for subsequent lots.

12-10. ABBREVIATED REGISTRATION WITH THE G/VLLD

a. In the conduct of a precision registration (fig 12-6), the operator uses the G/VLLD to determine corrections as described in the procedures for using the G/VLLD in the adjustment of fire. When the adjusting round is brought within 50 meters of the registration point (100 meters when the probable error in range is 25 meters or more), the adjustment procedures outlined in FM 6-30 are used.

b. The tactical situation or ammunition constraints may prohibit conducting a full-scale registration. In such cases, the FDO may direct that an abbreviated registration be conducted. An abbreviated registration may be ended when the observer believes that his correction would put the next round on the registration point. In an abbreviated registration, the operator *lases* the burst of the first adjusting round and transmits the correction. The FDC computes the data and fires a second adjusting round. The operator *lases* the burst of the second round and determines corrections. Registration data are based on the data computed to the final refinement data. If a time correction is required, one airburst is fired to establish the height of burst. The operator sends corrections to adjust the height of burst to 20 meters.

12-11. DETERMINATION OF A GFT SETTING FROM A REGISTRATION

a. When the time portion of a registration has been completed, the computer should circle the three elements of the adjusted data. These are adjusted deflection, adjusted elevation, and adjusted time.

b. Adjusted data and initial chart data from the registration are used to determine a GFT setting. Figure 12-5 shows a record of fire and the supporting registration/special correction work sheet for a precision registration, quick and time, conducted with a previous GFT setting.

RECORD OF FIRE

Observer BCH 23 CALL FOR FIRE AS/FFE/VS/S Tgt ALT REG PT2 316 GFT L39 Δ PS 0.10
Grid: ALT BTRY 355 DFT L7 100/R 19
Polar: Dir U/D VA 20/R 4
Shift: DIR 0800 Dir L/R +/- U/D Δ Si $\div$ 10 10m Si HOB Corr

FIRE ORDER PREC REG ON REG PT2, #3, LOTS XY & XP, CHG 4, 04 TI Df Corr L46 Si +5
INITIAL FIRE COMMANDS FM MF #3 ADD Rg 5360 Chf Df 2755 EI 331
Sp Instr Sh Lot XY Chg 4 Fz TI Df 2801 QE 336

MTD REG ON REG PT2, Q4 TI, 2 LOTS Δ T (400) PER (6.25) TF Q4 TI, 2 LOTS in Eff Ammo Exp ①

Tgt	Location	Priority	Firing Unit	MF, Sh, Chg, Fz	PS Corr	TI	Chart Df	Df Corr (L46)	Df Fired	Chart Rg	HOB Corr	Si (+5)	EI	QE	Exp	Type
R90	+400						2714	L46	2760	5690		+5	358	363	②	
							2720	L46	2766	5600		+5	351	356	③	
							2719	L46	2764	5640		+5	354	359	④	
②	-25	②					2720	L46	2766	5620		+5	352	357	⑥	
							2718	L46	2764	5640		+5	354	359	⑦	XYL
							2715	L46	(2761)	5630		(354)				
AS REG PT2	TI	RPT	F2 TI								+4	+9	354	363	①	
③			RPT	③										363	④	TIL
			UIO		-0.1 (20.5)											
REC AS TI REG PT2	OBSERVE															
SECOND LOT				① LOT XP								+5	354	359	①	
②	L10	-50					2716	L46	2762			+5	348	353	②	
							2715	L46	2761		+5	351	355	④		
							2716	L46	2762		+5	348	353	⑤	XP	
①		-25														
+10 REC -0.1 (20.6) 2715 L46 (2761) +5 (349)																
AS REG PT2 EM EM OLD GFT SETTING USED TO REG GFT A: CHGY LOT XY RG 5300 E 6326 T, 19.1 GFT OF CORR L39																
Btry	A	DTG	5/22/84	Tgt	REG PT 2	Replot Grid	Replot Alt									
DA FORM 4504 1 OCT 78 REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE																
FOR USE OF THIS FORM, SEE FM 6-40 THE PROponent AGENCY IS TRADOC																

SECTION I. REGISTRATION COMPUTATION

ACHIEVED RANGE				DEFLECTION CORRECTION			
1	CHART RANGE	3360	(10 METERS)	7	CORRECTED DEFLECTION (REGISTRATION)	2761	(1 MIL)
2	REGISTERING PIECE DISPLACEMENT (F - B)	-60	(10 METERS)	8	REGISTERING PIECE DISPLACEMENT CORRECTION (5) (L - R)	+8	(1 MIL)
3	ACHIEVED RANGE (1) + (2)	5200	(10 METERS)	9	ADJUSTED DEFLECTION (7) + (8)	2768	(1 MIL)
REGISTERING PIECE DISPLACEMENT CORRECTION				10	CHART DEFLECTION	2755	(1 MIL)
4	LATERAL DISPLACEMENT (L - R)	40	(5 METERS)	11	TOTAL DEFLECTION CORRECTION (9) (10) (L - R)	214	(1 MIL)
5	ACHIEVED RANGE (3)	520	(10 METERS)	12	DRIFT CORRECTION (- ADJUSTED ELEVATION) (L)	27	(1 MIL)
6	REGISTERING PIECE DISPLACEMENT CORRECTION (4) - (5) (L - R)	28	(1 MIL)	13	GRAPHICAL FIRING TABLE (GFT) DEFLECTION CORRECTION (11) (12)	26	(1 MIL)
GFT SETTING (MANUAL METHOD)				DEFLECTION CORRECTION			
14	GFT	A	CHARGE 4 LOT XY RANGE 5300 ELEVATION 354 TIME 20.8	TOTAL GFT			
15	GFT	A	CHARGE 4 LOT XP RANGE 3300 ELEVATION 349 TIME 20.5	L13 L6			
16	GFT		CHARGE LOT RANGE ELEVATION TIME				

GFT SETTING

Figure 12-5. Multilot precision registration.

RECORD OF FIRE

Observer BCH 23 CALL FOR FIRE AS/FFE/VS/S Tgt TGT 370 Δ PS .11
Grid: BTRY 355 100/R DFT L4
Polar: Dir U/D VA VI +15 20/R
Shift: DIR 0800 Dir L/R +/- U/D Δ Si $\div$ 10 10m Si HOB Corr

FIRE ORDER ABB REG, TGT ACT 7827, #3 LOT XY, CHG 4, Q4 TI Df Corr L11 Si +5
INITIAL FIRE COMMANDS FM MF #3 ADD Rg 3300 Chf Df 3373 EI 199
Sp Instr Sh Lot XY Chg 4 Fz TI Df 3384 QE 204

MTD ABB REG TGT ACT 7827, Q4 TI Δ T (25) TF Q4 TI in Eff Ammo Exp ①

Tgt	Location	Priority	Firing Unit	MF, Sh, Chg, Fz	PS Corr	TI	Chart Df	Df Corr (L11)	Df Fired	Chart Rg	HOB Corr	Si (+5)	EI	QE	Exp	Type
Q448	L50	+150					3350	L11	3384	3440		+5	209	214	②	Q4
							3354	L11	3384	3470		(211)				
							3354	L11	3384	3470		+6	+11	211	223	①
AS REG PT TI	RPT		F2 TI													
REC AS TI	Reg PT	Em	Em													

Btry A DTG 5/22/84 Tgt AC 7827 Replot Grid Replot Alt

DA FORM 4504 1 OCT 78 REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE

FOR USE OF THIS FORM, SEE FM 6-40; THE PROponent AGENCY IS TRADOC

REGISTRATION/SPECIAL CORRECTION WORK SHEET

For use of this form, see FM 6-40, proponent agency is TRADOC

SECTION I. REGISTRATION COMPUTATION

ACHIEVED RANGE				DEFLECTION CORRECTION			
1	CHART RANGE	3300	(10 METERS)	7	CORRECTED DEFLECTION (REGISTRATION)	3365	(1 MIL)
2	REGISTERING PIECE DISPLACEMENT (F - B)	-10	(10 METERS)	8	REGISTERING PIECE DISPLACEMENT CORRECTION (5) (L - R)	+17	(1 MIL)
3	ACHIEVED RANGE (1) + (2)	3290	(10 METERS)	9	ADJUSTED DEFLECTION (7) + (8)	3382	(1 MIL)
REGISTERING PIECE DISPLACEMENT CORRECTION				10	CHART DEFLECTION	3373	(1 MIL)
4	LATERAL DISPLACEMENT (L - R)	55	(5 METERS)	11	TOTAL DEFLECTION CORRECTION (9) (10) (L - R)	29	(1 MIL)
5	ACHIEVED RANGE (3)	3290	(10 METERS)	12	DRIFT CORRECTION (- ADJUSTED ELEVATION) (L)	24	(1 MIL)
6	REGISTERING PIECE DISPLACEMENT CORRECTION (4) - (5) (L - R)	17	(1 MIL)	13	GRAPHICAL FIRING TABLE (GFT) DEFLECTION CORRECTION (11) (12)	25	(1 MIL)
GFT SETTING (MANUAL METHOD)				DEFLECTION CORRECTION			
14	GFT	A	CHARGE 4 LOT XY RANGE 3290 ELEVATION 211 TIME 13.0	TOTAL GFT			
15	GFT		CHARGE LOT RANGE ELEVATION TIME	L9 L5			
16	GFT		CHARGE LOT RANGE ELEVATION TIME				

Figure 12-6. Abbreviated registration by use of the G/VLLD.

12-12. MET + VE WITH A CHECK ROUND

Met + VE with a check round is an abbreviated form of a precision registration in which adjusted data are determined with one or more rounds.

a. The first step of this procedure is to obtain firing data for the round(s) to be fired by solving a met to target (chap 10).

b. After the round has been fired and the observer's refinement has been obtained, determine the adjusted data by plotting the refinement and determining data to that point. Total corrections and the GFT setting are obtained in the same manner as in a precision registration—by comparing "chart" to "adjusted" and compensating for any piece displacement.

Section III HB/MPI REGISTRATIONS

12-13. OBJECTIVE

a. When it is necessary to register, clearly defined and accurately located registration points may be limited or not available. Dense vegetation or ground fog may prevent the observers from seeing the ground. At night, the adjustment of fire on a registration point is impossible without some type of illumination. The high-burst or mean-point-of-impact registrations overcome these problems.

b. In both the HB and the MPI registrations, a number of rounds (usually six) are fired with the same set of firing data. These rounds are observed by two observers in surveyed positions, usually designated O1 and O2, who can measure the direction to each bursting round. The MBL is determined and plotted on the basis of the observer's average directions. Chart data are then determined and compared to the adjusted data that were fired.

c. The HB registration is fired by use of time-fuzed rounds and offers an advantage

over the MPI by allowing the FDC to determine a fuze correction for future missions. The high burst is also easier to observe, especially at night, and registration corrections may be determined in areas where the observers cannot see the ground.

d. If the unit can use G/VLLD-equipped observers, the HB/MPI registration can be accomplished with one observer during wartime or with two observers during peacetime. Laser safety requirements for peacetime may prohibit G/VLLD live lasing above the skyline. The G/VLLD registration with one observer is handled as a radar registration in BCS or FADAC, because the observer can provide burst grid and altitude when equipped with the FIST digital message device. In peacetime, two observers equipped with laser-safe G/VLLDs (shorting plugs installed) could provide azimuth and vertical angle information to the fire direction center. This registration is computed as an HB/MPI registration by using two observers. If no G/VLLD observers are available, observers equipped with aiming circles or battery commander periscopes can be used.

e. The requirement for surveyed observer locations is the primary limitation of the HB and MPI registrations.

f. There are six basic steps in an HB/MPI registration.

- (1) Select an orienting point.
- (2) Orient the observers.
- (3) Determine firing data to the orienting point.
- (4) Fire the HB/MPI registration.
- (5) Determine the mean burst location.
- (6) Determine chart data and registration corrections.

12-14. SELECTING AN ORIENTING POINT

a. The S3 or FDO selects an orienting point at which all of the rounds will be fired. This point may be located at a grid intersection for convenience. The orienting point is only a temporary point on the firing chart. After the firing data have been determined, the orienting point is no longer needed.

b. For an HB and an MPI registration, the orienting point should—

- (1) Be visible to both observers.
- (2) Be close to the center of the area of responsibility unless eight-direction met is to be used to determine a valid GFT setting.
- (3) Ensure the apex angle is greater than 150 mils (preferably 300 mils). The apex angle is the angle formed by the lines from each observer to the orienting point (fig 12-7).
- (4) For an MPI registration, the orienting point should be in a relatively flat (level) area that is free of obstructions.

(5) For an HB registration, the orienting point must be high enough to ensure an airburst. Fifty meters above the ground is usually sufficient, but the selected height of burst must be at least 2 PE_{HB} above the ground. For example, the FDO for an M109A3 unit has selected an orienting point for an HB registration. The range to the orienting point is 4,550 meters. The unit will

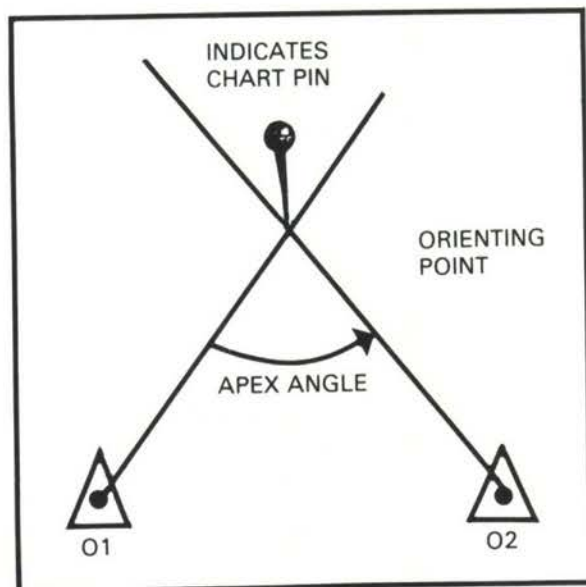


Figure 12-7. Apex angle.

be firing charge 4GB. Enter table G of the TFT for charge 4 with the range expressed to the nearest 500 meters. Extract an 8-meter PE_{HB} from column 5. Two probable errors would be 16 ($2 \times 8 = 16$), rounded up to the nearest 10 meters ($16 \approx 20$); thus, the lowest height of burst that should be selected is 20 meters.

c. The HB or MPI registration starts with the fire order: **HIGH BURST REGISTRATION AT GRID 6137, HEIGHT OF BURST 50, NUMBER 4, LOT XY, CHARGE 4, FUZE TIME, AT MY COMMAND. HIGH BURST REGISTRATION AT GRID 6137** notifies the FDC of the type of mission to be fired (an HB registration) and the location of the orienting point (grid 6137). **HEIGHT OF BURST 50 METERS** tells the VCO the desired height of burst above ground level (at grid 6137) for determining site. **NUMBER 4** designates the piece that will register. **LOT XY** designates the registration lot. **CHARGE 4** designates the charge to be used. **FUZE TIME** indicates the fuze type. **AT MY COMMAND** means that the FDO wants to control the exact time each round will be fired. **AT MY COMMAND** is used to ensure that each observer sees the burst from each round. Any elements of the fire order already addressed in unit SOP need not be announced to the fire direction center.

12-15. ORIENTING THE OBSERVERS

a. After the orienting point has been selected and the fire order has been issued, the two observers must be told where to look to observe the rounds. The observer's locations are plotted on the firing chart, and the direction and distance from each observer to the orienting point are measured. The VCO uses the distances and the VI between each observation post and the orienting point to determine the vertical angle for each observer. The vertical angle is determined by use of the C- and D-scales of the graphical site table.

b. A message to observer is sent to both observers. The message to observer contains the information needed to tell the observers where to orient their instruments to see the bursts. It is recorded on DA Form 4201 (High-Burst [Mean Point of Impact] Registration). The message contains the following parts:

(1) A warning order (OBSERVE HIGH-BURST REGISTRATION). The warning order instructs the observers to prepare to observe a registration and tells them for what type of registration they are preparing.

(2) Orienting data for observer O1 (O1 DIRECTION 0383, VERTICAL ANGLE PLUS 17). The HCO has measured the chart data from O1 to the orienting point. The direction reported to the observer is the direction determined on the firing chart. The VCO determines the altitude of the grid intersection (grid 6137) and then adds the HOB to determine the altitude of the orienting point.

EXAMPLE:

Orienting point altitude = ground altitude + HOB

Ground altitude	375
+ HOB	+ 50
Orienting point altitude	425

The VCO subtracts the altitude of the observer (370) from the altitude of the

orienting point to determine the VI (425 - 370 = +55). The VCO determines O1's vertical angle (+17) by use of the C- and D-scales of the GST, the VI (+55), and the distance measured by the HCO (3,380 meters). Knowing the vertical angle and direction reported to observer O1 will enable O1 to orient on the orienting point.

EXAMPLE:

$$W \div R = m$$

$$VI \div \text{distance} = VA$$

$$(+55) D\text{-scale} \div (3.38) = +16.56 \text{ (M-gage point, D-scale)} \approx +17$$

(3) A directive to O1 to measure the vertical angle. O1 is normally the control observation post. It has been more accurately located and has the most experienced observer. Observer O1 measures the vertical angles that will be used to compute the altitude of the mean burst location. Only one observer's vertical angle is required.

(4) Orienting data for observer O2. The HCO measures the chart data from O2 to the orienting point. The VCO subtracts the altitude of the observer (391) from the altitude of the orienting point (425) to determine the VI (425 - 391 = +34). The VCO determines O2's vertical angle (+11) by use of the C- and D-scales of the GST, the VI (+34), and the distance measured by the HCO (3,060 meters). Knowing the vertical angle and direction reported to observer O2 will enable O2 to orient on the orienting point.

(5) A directive to the observers to report when they are ready to observe. When the observers report they are ready to observe, the FDC can begin the registration.

c. Each observer orients his instrument on the direction and vertical angle announced to him and reports to the FDC when he is ready to observe.

d. The survey section provides the direction and distance from O1 to O2. The following are provided:

Direction O1 to O2	1,464 mils
Distance O1 to O2	2,475.1 meters

The computer records this information on DA Form 4201 (fig 12-8) and determines the direction from O2 to O1 by adding (or

subtracting) 3200 to (from) the direction from O1 to O2.

12-16. DETERMINING FIRING DATA

a. The HCO determines the range and deflection from the battery to the orienting

point and announces the data to the computer. The computer records the data on the record of fire (fig 12-9).

b. The VCO subtracts the altitude of the battery (355) from the altitude of the orienting point (425) to determine the VI (425 - 355 = +70). The VCO determines the site to be +17 by

HIGH BURST (MEAN POINT OF IMPACT) REGISTRATION			
For use of this form, see FM 6-40; the proponent agency is US Army Training and Doctrine Command.			
COMPUTATION OF HB (MPI) LOCATION			
Message to Observers OBS HB REG O1 DIR 0383 VA +17 MEASURE THE VA O2 DIR 5985 VA +11 REPORT WHEN READY TO OBSERVE	Dis O1 → O2	Az O1 → O2	1464
	2475.1	+	3200
		-	
		O2 → O1	4664

Figure 12-8. Message to observer.

RECORD OF FIRE																																	
CALL FOR FIRE										GROUND ALT 375					△ FS																		
Observer	AF/FE/IS/S				Tgt					HOB		+50		100/R	22																		
Grid:										TGT		425		/R																			
Polar: Dir	Dis				U/D	VA				BTRY		355		20/R																			
Shift	Dir				L/R	+/-				U/D	VI		+70																				
										Si ÷ 10		10m Si		HOB Corr																			
FIRE ORDER HIGH BURST REG @ GRID 16137 HOB +50 #4 CH64										Df Corr		L5		Si		+17																	
INITIAL FIRE COMMANDS										FM		MF		#4 ADJ		Rg		4550		Chf Df		3222		EI		270							
Sp Instr										AMC		Sh		Lot		Chg		4		F/T		Ti		162		Df		3227		QE		297	
MTO										4 T		PER		TF		in Eff		Ammo Exp															
SUBSEQUENT FIRE COMMANDS																																	
Tgt	Location	Priority	Firing Unit	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si ()	EI	QE	Exp	Type																	
(SEE ATTACHED DA 4201)																																	
TGT ALT	425					01	DIR 0383			DIS	3380					VA +17																	
O1 ALT	320																																
VI	755																																
TGT ALT	425					02	DIR 5985			DIS	3060					VA +11																	
O2 ALT	321																																
VI	+34																																
Btry A DTG 5/22/84 Tgt Replot Grid Replot Alt																																	
DA FORM 4504 REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE FOR USE OF THIS FORM, SEE FM 6-40; THE PROPOS AGENCY IS TRADOC																																	

Figure 12-9. High-burst record of fire.

using the D-scale and the site-range scale (charge 4, TAG) of the GST. The VCO announces the site to the computer.

c. The computer records the site on the record of fire and determines and announces the fire commands to the battery. No GFT setting is available.

12-17. FIRING THE HB/MPI REGISTRATION

a. After both observers have reported they are ready to observe and the base piece announces it is ready to fire, the FDO begins firing the registration. The first round that is fired may not be observed by either of the observers. Nonstandard conditions may cause the round to burst outside the field of vision of the observer's instrument. After the first round, both observers should adjust their instruments so that the actual burst location of the round is in the center of the field of vision of their instruments. There may be times when the nonstandard conditions cause the round to land behind a hill or in a ravine (out of sight of one or both observers). If this happens, the firing data to the orienting point are changed until both of the observers can see the bursting rounds. Remember, if the orienting point is changed to a location that is not near the original orienting point, new orienting data must be sent to the observers (a new message to observer) so they can orient on the new location. Sometimes, graze bursts will occur at the start of a high-burst registration. The observer's data for these rounds cannot be used to determine the mean burst location. In this case, the HOB is raised by at least 2 probable errors in HOB (table G of the TFT). The firing data are recomputed.

b. Once the observers have oriented on the actual location of the bursting rounds, the firing data are not changed. All rounds used to locate the MBL must be fired with the same set of firing data. Once the observers have located the actual burst and are oriented, the method of fire may be changed to **NUMBER 4, 6 ROUNDS** (or however many rounds are required) **AT** (so many) **SECONDS**. The time interval between rounds must be long enough for the observers to identify each round and record the data to that round.

c. When both observers have reported that they have observed the bursting round, the computer transfers the firing data to DA Form 4201 and writes "See attached record of high burst (MPI)" on the record of fire. All remaining information from the registration is recorded on the DA Form 4201.

d. After each round fired has been observed, the observers report the direction to each round from their location, and observer O1 reports the vertical angle from his location. The computer records the data on DA Form 4201 as they are sent by the observers. The FDO must determine if any rounds fired were erratic and should be disregarded. There are no exact rules for determining which rounds are erratic. The following are three ways in which erratic rounds may be determined. They are meant as guidelines only.

(1) Determine the mean burst location by use of graphic intersection (para 12-18). Using the range to the mean burst location expressed to the nearest 500 meters, determine the PE_R and PE_D and construct a box ($8 PE_R \times 8 PE_D$) centered over the MBL and along the gun-target line. Reject any rounds that plot outside this box (fig 12-10).

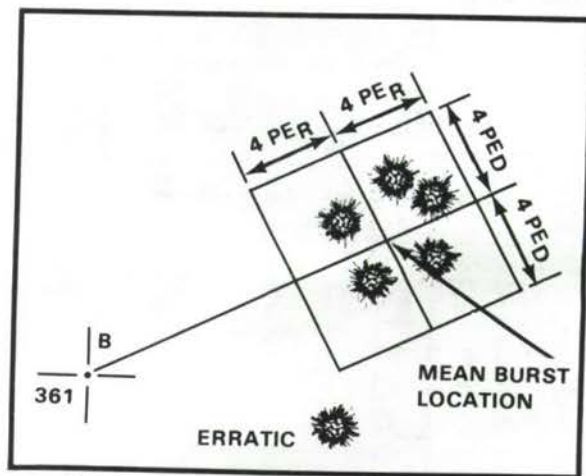


Figure 12-10. PE_R box for a high-burst registration.

(2) At the range to the mean burst location expressed to the nearest 500 meters, determine the PE_{HB} . Using the O1's reported vertical angles, the measured distance from O1 to the MBL, and the ground altitude, determine the altitude of the mean burst

location. Determine the altitude of each round, and compare this altitude with the average altitude. Reject any round that falls outside the average altitude ± 4 PE_{HB}.

(3) The FDO may use his judgment and experience in determining if a round should be rejected. Care must be taken to ensure that erratic rounds are not used or that usable rounds are not rejected. If a round is considered erratic because of the reported direction or vertical angle from one observer, the data from the other observer must also be disregarded.

12-18. DETERMINING THE MEAN BURST LOCATION

a. The observer's measured azimuths are listed, in order for each round, on DA Form 4201 as they are sent to the FDC by the observers (fig 12-11). As the round is fired, the round number is circled to record the expenditure of rounds during the registration. Some rounds may be considered

erratic. Erratic rounds are crossed out, and rounds may be fired to replace them.

b. After the data from the six usable rounds have been recorded, the FDC determines the mean burst location. The location is determined by one of three methods. The methods are listed in increasing order of accuracy and time of computation. The method used by the FDC will be determined by the tactical situation. In most cases, the graphic intersection method is acceptable. However, when it is necessary to increase accuracy (nuclear fire mission), the other methods should be used if time permits.

(1) **Graphic intersection.** The observer's average directions are drawn on the firing chart. The point at which the directions intersect is the mean burst location.

(2) **Polar plot.** The direction and distance from O1 to the MBL are determined, and the MBL is polar plotted on the firing chart.

(3) **Grid coordinates.** The actual grid coordinates of the mean burst location are computed and then plotted on the firing chart.

c. Procedures for use of the graphic intersection method are as follows:

(1) The usable observer readings are totaled on the form, and the average reading is obtained by dividing the total by the number of usable rounds (in this case six). The averages are determined to the nearest mil.

(2) Using the RDP, the HCO sets off the average direction from O2 to the HB and draws a construction line along the left edge of the RDP with a 6H pencil. He then sets off the average direction from O1 to the HB. The point at which the two lines intersect is the mean burst location. A pin is placed at the MBL, and the distance from O1 to the HB is measured.

(3) The computer uses the distance from O1 to the MBL and O1's vertical angle to determine the altitude of the mean burst location.

Data Fired		Chg		4		DT	
Observer Readings							
Rd No	O1 Az	VA	O2 Az	O1			
①	0350	19	5975	Az O1 → HB (MPI)			
②	0352	21	5983	+ 6400 if necessary			
③	0353	19	5977	Total			
④	0362	22	5984	- Az O2 → HB (MPI)			
⑤	0360	21	5985	APEX 4			
⑥	0359	19	5976	Az O2 → HB (MPI)			
7				+ 6400 if necessary			
8				Total			
9				- Az O2 → O1			
10				Az O1 O2			
	2136	20	35880	Total			
	0356	20	5980	Average			

Figure 12-11. Observer's measured azimuth.

(a) The HCO uses the RDP and measures the distance from O1 to the mean burst location. He announces the result to the VCO (O1 DISTANCE 3450).

(b) The VCO uses O1's average vertical angle (+20), the distance (3450), and the GST to determine the VI between O1 and the MBL ($[+20 \times 3450]$, C- and D-scales of $\text{GST} = \text{VI} [+68 \text{ meters}]$). The VCO announces VI +68 METERS.

(c) The computer adds the VI to the altitude of O1 ($370 + [+68] = 438$). The altitude of the MBL is 438.

d. Procedures for use of the polar plot method are as follows:

(1) Determine the average observer readings as explained in paragraph c above.

(2) Using the next section of the form, determine the interior angles of a triangle formed by the two observers and the mean burst location (fig 12-12 and 12-13). If O1 is on the left of O2, cross out the section marked

O1 on the right. If O1 is on the right of O2, cross out the section marked O1 on left.

Note. O1 is left or right of O2 with respect to how they are looking at the orienting point.

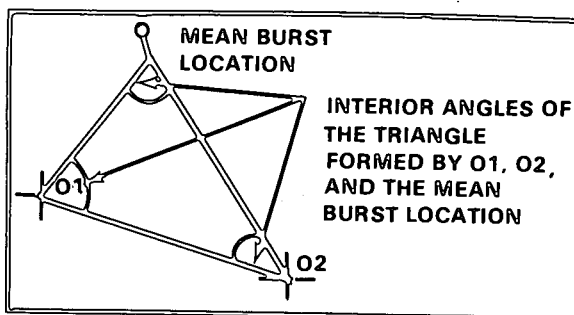


Figure 12-12. Determining interior angles.

(3) Completing the appropriate side of the form, determine the angle at O2 ($\angle$ at O2) (fig 12-13).

Interior Angles	
O1 on Left	O1 on Right
Az O1 → HB (MPI)	Az O2 → HB (MPI)
+6400 if necessary	+6400 if necessary
Total	Total
-Az O2 → HB (MPI)	-Az O1 → HB (MPI)
APEX $\angle$	APEX $\angle$
Az O2 → HB (MPI)	Az O2 → O1
+6400 if necessary	+6400 if necessary
Total	Total
-Az O2 → O1	-Az O2 → HB (MPI)
$\angle$ at O2	$\angle$ at O2
Total	Bearing = Az
Bearing = 6400 - Az	dE +
dE -	dN +
dN +	Az O1 → HB (MPI) - Bearing

Figure 12-13. Polar plot method.

(4) After the angle at O2 has been determined, compute the distance from O1 to the mean burst location by using logarithms found in TM 6-230. Use the section of the form labeled Distance O1 HB (MPI) to determine the distance O1 to the mean burst location (fig 12-14). You may also use a slide rule or a calculator to compute the distance from O1 to the mean burst location. Use the formula in figure 12-15.

Distance O1 HB (MPI)	
Log base O1 → O2	3 393 593
+ Log sin $\angle$ at O2	9 981 653
Sum (1)	3 375 246
- Log sin Apex Angle	9 839 007
diff = Log dist O1 HB (MPI)	3 536 239
Dist O1 → HB (MPI)	3 437

Figure 12-14. Determining the distance from O1 to the mean burst location.

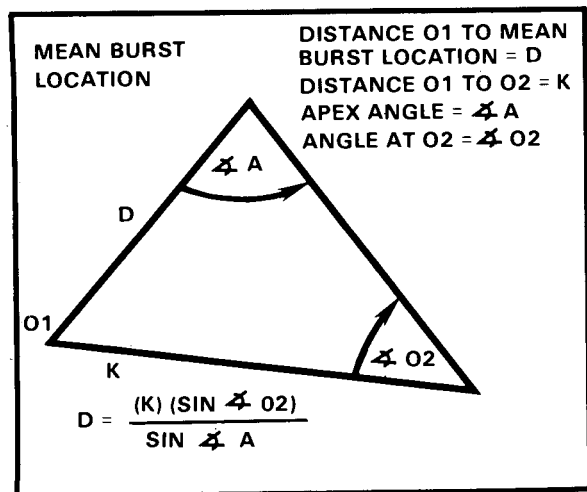


Figure 12-15. Computing the distance from O1 to the mean burst location.

(5) The distance from O1 to the mean burst location is expressed to the nearest 10 meters (3,437 meters $\approx$ 3,440 meters).

(6) The HCO places the vertex of the RDP on O1 and moves the RDP to the average direction determined for O1 to the mean burst location (0356 mils). The HCO places a pin at

the distance determined for O1 to the mean burst location (3,440 meters). This is the mean burst location.

(7) The VCO uses the average vertical angle determined for O1 (+20), the distance from O1 to the mean burst location (3,440 meters), and the GST to determine the VI between O1 and the MBL ($20 \times 3,440$ meters, C- and D-scales of GST = VI + 68). Add the VI (+68) to the altitude of O1 (370) to determine the altitude of the MBL ($370 + (+68) = 438$).

e. Procedures for use of the grid coordinate method are as follows:

(1) Compute the average directions, interior angles, and distance from O1 to the mean burst location as in paragraphs c and d above.

(2) Determine the bearing angle from O1 to the mean burst location. Using the diagram (with the top of the form representing north or 0 mils), draw a line approximately along the average azimuth from O1 to the mean burst location. Draw this line in one of the four quadrants of the diagram. In each quadrant are the instructions for determining the bearing angle in that quadrant (fig 12-16).

IC		4 at O2		1306		4 at C2	
0356 + 5980		Total		Bearing = 6400 - Az		Bearing = Az	
Distance O1 HB (MPI)		Average		dE - dN +		dE + dN +	
Log base O1 → O2		3 393 593				Az O1 → HB (MPI) - Bearing	
+ Log sin 4 at O2		9 981 653				Bearing	
Sum		3 375 246				Bearing	
- Log sin Apex Angle		9 839 007				Bearing	
diff = Log dist O1 HB (MPI)		3 536 239				Bearing	
Dist O1 → HB (MPI)		3 437		dE - dN -		dE + dN -	
Log of dE, dN, and dH							
Log dist O1 → HB (MPI)		3 536 239		Log dist O1 → HB (MPI)		3 536 239	
Log sin Bearing		9 534 572		Log cos Bearing		9 972 917	
Sum = Log dE		3 070 811		Sum = Log dN		3 509 156	
Coordinates of O1		E 59 748 0		N 33 872 0		H 370 0	
		+ dE		+ dN		+ dH	
Location of HB (MPI)		E 60 925 1		N 37 101 7		H 437 5	
COMPUTATION OF GFT SETTING							
Alt HB (MPI)		QE fired		Chart data to HB (MPI) location		Df corr	
- Alt Btry		- Site VI/HB (MPI) Rq		Deflection _____ m Range _____ M			
VI		Adj Elev		GFT _____ Charge _____ Lot _____			
				Range _____ Elevation _____ Time _____			

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Figure 12-16. Computation of mean burst location.

(3) Using the log of difference in easting (dE), difference in northing (dN), and difference in height (dH) portion of the form and the surveyed coordinates of O1, determine the coordinates of the mean burst location. The distances determined for dE and dN are either subtracted from or added to the surveyed coordinates of O1 depending on the quadrant entered by the bearing angle. Each quadrant lists whether dE and dN are plus (+) or minus (-). If the average VI is plus, the value of dH is subtracted from O1's altitude. A slide rule or a calculator may be used to compute the MBL and altitude.

(4) The MBL is plotted on the chart in the same manner as on any surveyed location.

12-19. DETERMINING CHART DATA

a. After the MBL has been plotted on the chart, the HCO measures the range and deflection to the plotted position from the battery that fired the mission. The range and deflection measured are the chart range and

chart deflection and are recorded as shown in figure 12-17.

b. The VCO determines site by determining the VI between the MBL and the battery. Using the GST, divide this value by the chart range.

12-20. DETERMINING ADJUSTED DATA

a. Adjusted Elevation. The quadrant elevation used to fire the six usable rounds in the registration is the adjusted quadrant elevation. The site is subtracted from the adjusted quadrant elevation, and the result is the adjusted elevation (fig 12-18).

b. Adjusted Deflection.

(1) If the firing weapon is over battery center, the deflection used to fire the six usable rounds in the registration is the adjusted deflection.

Location of HB (MPI)		-dE													
E		N		H											
COMPUTATION OF GFT SETTING															
Alt HB (MPI)		QE fired		Chart data to HB (MPI) location Deflection <u>3237</u> m Range <u>4620</u> M								Df corr			
-Alt Btry		- Site VI/HB (MPI) Rg		GFT " " Charge " Lot "											
VI	+	Adj Elev		Range " Elevation " Time "											
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Figure 12-17. Measured range and deflection.

COMPUTATION OF GFT SETTING															
Alt HB (MPI)	<u>438</u>	QE fired	<u>287</u>	Chart data to HB (MPI) location Deflection <u>3237</u> m Range <u>4620</u> M								Df corr			
-Alt Btry	<u>355</u>	- Site VI/HB (MPI) Rg	<u>+20</u>	GFT " <u>A</u> " Charge <u>4</u> Lot <u>XV</u>											
VI	<u>83</u>	Adj Elev	<u>267</u>	Range <u>4620</u> Elevation <u>267</u> Time <u>16.7</u>											
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											R10	TOT			
											LS	DFT			
											R15	GFT			

Figure 12-18. Computation of a GFT setting.

(2) If the firing weapon is not over battery center, the deflection used to fire the six usable rounds is the correct deflection. The adjusted deflection is determined in the same manner as the adjusted deflection for a precision registration when the piece is not over battery center (fig 12-19).

c. Adjusted Time.

(1) If the VI between the battery and the MBL is less than or equal to 100 meters, the

fuze setting used to fire the six usable rounds is the adjusted time.

(2) If the VI is greater than 100 meters, the adjusted time must be modified to correct for an inaccuracy introduced by the large complementary angle of site (fig 12-20). The 100-meter VI is only a rule of thumb. The CAS may affect adjusted time at VIs less than 100 meters. The FDO should check the effects of CAS any time he feels it will affect adjusted time.

REGISTRATION/SPECIAL CORRECTION WORK SHEET									
For use of this form, see FM 6-40, proponent agency is TRADOC									
SECTION I. REGISTRATION COMPUTATION									
ACHIEVED RANGE					DEFLECTION CORRECTION				
1	CHART RANGE	4620 (10 METERS)			7	CORRECTED DEFLECTION (REGISTRATION)	3227 (1 MIL)		
2	REGISTERING PIECE DISPLACEMENT (F - B)	+20 (10 METERS)			8	REGISTERING PIECE DISPLACEMENT CORRECTION (6) (L - R)	L28 (1 MIL)		
3	ACHIEVED RANGE (1) + (2)	4640 (10 METERS)			9	ADJUSTED DEFLECTION (7) + (8)	3255 (1 MIL)		
REGISTERING PIECE DISPLACEMENT CORRECTION					10	CHART DEFLECTION	3237 (1 MIL)		
4	LATERAL DISPLACEMENT (L R)	L130 (5 METERS)			11	TOTAL DEFLECTION CORRECTION (9) (10) (L - R)	L18 (1 MIL)		
5	ACHIEVED RANGE (3)	4640 (10 METERS)			12	DRIFT CORRECTION (1 - ADJUSTED ELEVATION) (L)	L5 (1 MIL)		
6	REGISTERING PIECE DISPLACEMENT CORRECTION (4) + (5) (L - R)	L28 (1 MIL)			13	GRAPHICAL FIRING TABLE (GFT) DEFLECTION CORRECTION (11) (12)	L13 (1 MIL)		
GFT SETTING (MANUAL METHOD)									
14	GFT	CHARGE	LOT	RANGE	ELEVATION	TIME	DEFLECTION CORRECTION		
15	A	4	XY	4640	267	162	TOTAL	GFT	
16							L18	L13	
REMARKS REG PIECE DISP L130 B20									

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Figure 12-19. Registration/special correction work sheet for the high-burst registration.

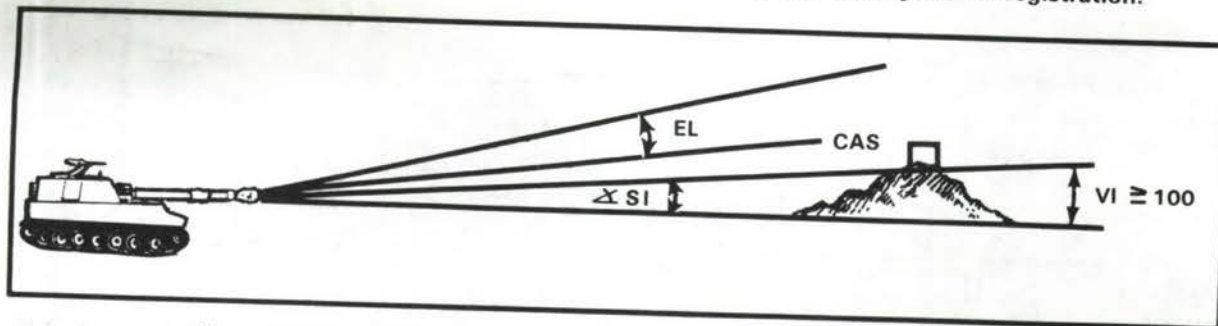


Figure 12-20. Adjusted time with a vertical interval greater than 100.

(a) Fuze setting is determined as a function of the elevation and CAS. When the VI is less than or equal to 100 meters, the CAS is so small that it has little effect on the quadrant and fuze setting fired and is disregarded. The CAS is small when compared to the elevation and will not affect the fuze setting.

(b) If the VI is greater than 100 meters, the value of the CAS becomes increasingly large and begins to affect the fuze setting. In this case, the CAS must be added to the elevation to determine the proper fuze setting.

(c) As the CAS increases, the fuze setting must be increased to reach the desired bursting location. If the effect of CAS is not included in the fuze setting, the projectile will burst before reaching the desired location.

(d) The adjusted time when the VI is greater than 100 meters is determined as follows:

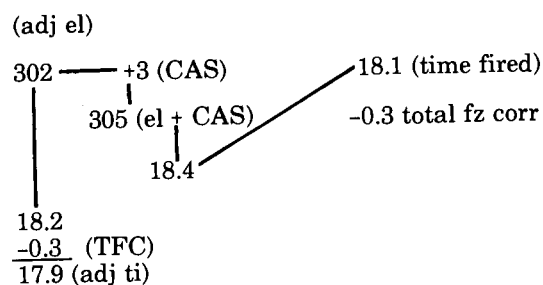
- Determine site and angle of site to the mean burst location by use of the graphical site table.
- Determine the CAS by subtracting the angle of site from site ($si - \angle si = CAS$).
- Add the CAS to the adjusted elevation, and determine the fuze setting corresponding to this value ($FS \approx el + CAS$).
- Subtract the fuze setting corresponding to elevation + CAS from the fuze fired to determine the total fuze correction ($[FS \text{ fired}] - [FS \approx el + CAS] = \text{tot fz corr}$).
- Add the total fuze correction to the fuze setting corresponding to the adjusted elevation. The result is the adjusted

time ($[FS \approx \text{adj el}] + [\text{tot fz corr}] = \text{adj ti}$).

EXAMPLE:

Given: Registration charge: charge 4
Adjusted elevation: 302
Vertical interval: +150
Chart range: 5,000 meters
Fuze setting fired during registration: 18.1

- Determine site and the angle of site (VI = 150, charge 4 at 5,000 meters, GST site-range scale = 134). (Angle of site VI = 150, C- and D-scales of GST at range 5000 = +31.)
- Determine CAS. Site - angle of site = CAS. ($+34 - [+31] = +3$).
- Determine the elevation + CAS. Adjusted elevation + CAS = $el + CAS$ ($302 + [3] = 305$).
- Determine the fuze setting corresponding to elevation plus CAS. Place the MHL of GFT on 305, and read the fuze setting of 18.4 under the MHL.
- Determine the total fuze correction. Fuze setting fired in registration - fuze setting corresponding to the elevation + CAS = total fuze correction ($18.1 - 18.4 = -0.3$).
- Determine adjusted time. Fuze setting corresponding to adjusted elevation + total fuze correction = adj time ($18.2 - 0.3 = 17.9$).



Section IV RADAR REGISTRATIONS

12-21. EMPLOYMENT

Field artillery radars can conduct registrations. The conduct of a radar

registration is similar to that of other HB/MPI registrations. The unique procedures and requirements for the

AN/MPQ-4 and the AN/TPQ-36/37 radar systems are discussed in this section.

12-22. ADVANTAGES

The advantages of a radar registration are as follows:

- a. It requires only one observation post—the radar.
- b. It requires less survey, fewer communications facilities, and less coordination.
- c. It can be conducted quickly.
- d. It can be conducted during periods of poor visibility. The AN/MPQ-4 radar may conduct only MPI registrations during periods of poor visibility.
- e. It gives the grid and altitude of the MBL or the grid and altitude of each round.

12-23. CONDUCTING A RADAR REGISTRATION

a. The six steps in conducting a radar registration are—

- (1) Selecting an orienting point.
- (2) Orienting the radar.
- (3) Determining firing data to the orienting point.
- (4) Firing the HB/MPI registration.
- (5) Determining the mean burst location.
- (6) Determining chart data and registration corrections.

b. Radar registrations with the AN/TPQ-36/37 radar require only an electrical line of sight from the radar to the orienting point. High-burst registrations conducted with the AN/MPQ-4 radar require an optical line of sight and an electrical line of sight. The MPI registrations with the AN/MPQ-4 radar require only an electrical line of sight.

c. The AN/TPQ-36/37 radar operator reports the grid and altitude of each burst location. The AN/MPQ-4 radar operator reports the grid and altitude of the MBL after the last round has been located.

12-24. SELECTING AN ORIENTING POINT

Coordination and mutual understanding must exist between the FDC and radar personnel in the choice of an orienting point.

a. High Burst.

(1) **AN/MPQ-4 radar.** For a high-burst registration conducted with the AN/MPQ-4 radar, the selected orienting point must be optically visible from the radar. For the radar operator to optically observe elevation deviations above and below the selected point, the pointing elevation of the radar must be at least 10 mils above the elevation to the radar screening crest. The radar operator measures the elevation from the radar along the azimuth to the selected burst point by sighting through the optical telescope.

(2) **AN/TPQ-36/37 radar.** A high-burst registration conducted with the AN/TPQ-36/37 requires only an electrical line of sight to the selected point. The on-board computer controls the radar to enable it to intersect the trajectory above the screening crest. The radar will track the round until the airburst is detected.

b. Mean Point of Impact.

(1) A characteristic of the radar MPI registration is that the rounds usually cannot be observed at impact, because the radar is usually positioned behind a mask.

(2) The AN/MPQ-4 radar must observe the round at some point in space where the round passes through the radar beam. This point in space is called the selected datum plane—the theoretical horizontal plane of the radar beam from which radar personnel in the AN/MPQ-4 radar system can compute the location of the usable rounds (fig 12-21).

(3) The AN/TPQ-36/37 radar systems set up a “window” through which the projectile will pass (fig 12-22). The window is referred to as the friendly fire search fence. The search fence allows for the best probability of detection. After the orienting point has been selected, the FDO issues his fire order.

(a) When conducting an MPI registration (observed with an AN/TPQ-36/37 radar), the orienting point must be in the friendly fire search fence. Therefore, the orienting point must include an HOB value. Firing data for the AN/TPQ-36/37 radar MPI registration will not include the 20/R value, and fuze quick will be fired.

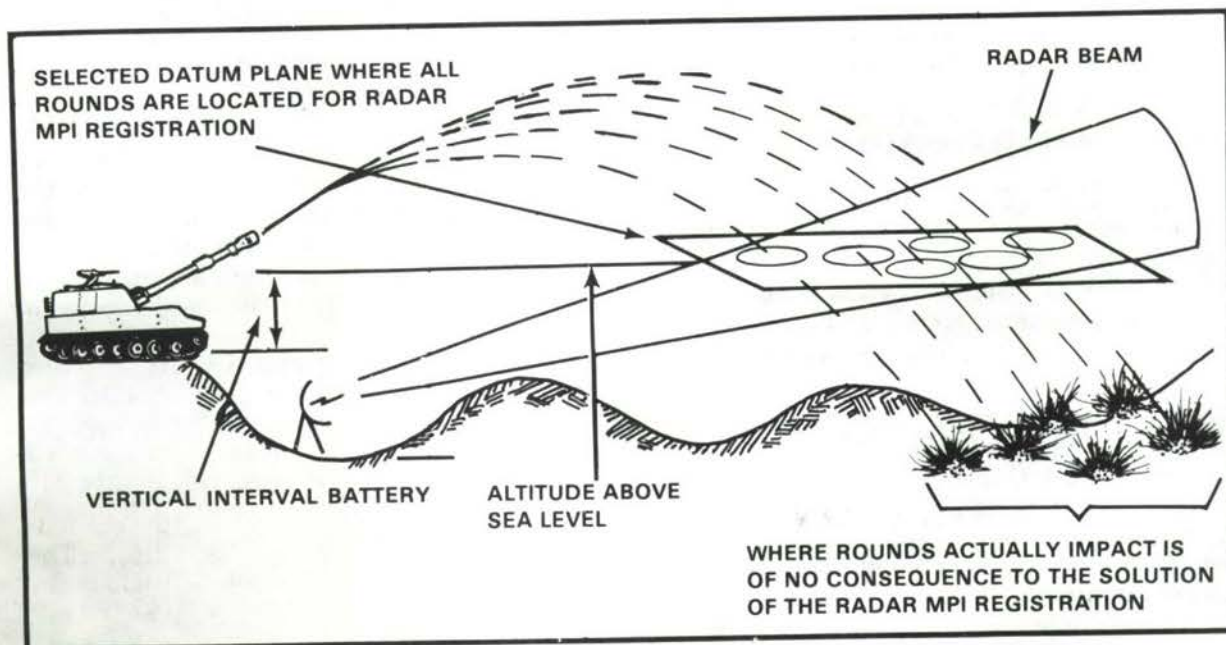


Figure 12-21. The selected datum plane—AN/MPQ-4 radar.

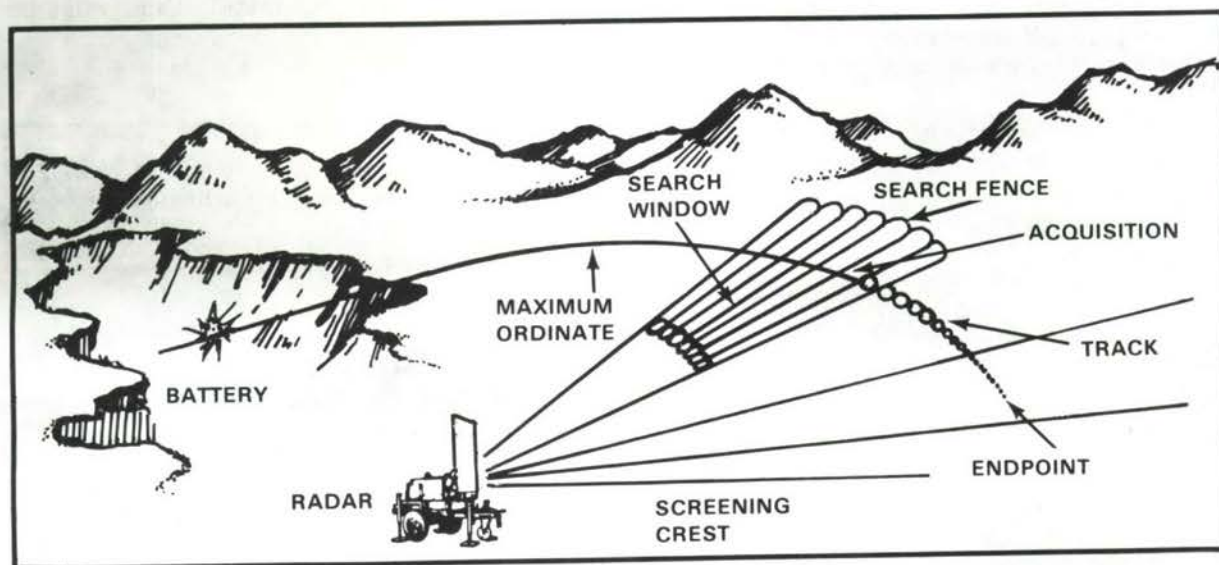


Figure 12-22. Projectile tracking—AN/TPQ-36/37 radar.

(b) Because of the size of the radar's memory queue, no more than six rounds should be fired without coordination with the radar section. Rounds should be fired at 30-second intervals with an angle T of less than 1,000 mils.

(c) The projectile is tracked until it reaches the datum plane height. The grid and altitude of the projectile at that point are reported to the fire direction center.

12-25. RADAR MESSAGE TO OBSERVER

The message is to inform the radar operator of the mission and to provide the information required to prepare the radar set for the mission. The message is slightly different for each radar system. If a DMD is available, the DMD format will be used.

a. Warning Order. The warning order must always be included in the message to observer. It is **OBSERVE HIGH BURST** (or **MPI**) **REGISTRATION FOR** (unit call sign). This informs the radar of the type of registration and for whom it is to be fired. Communications security procedures must be observed when transmitting information.

b. Orienting Data.

(1) To orient the AN/MPQ-4 radar, the radar operator is provided with the grid or polar data to the orienting point.

(2) To orient the AN/TPQ-36/37 radar, the radar operator is provided with the following:

(a) Grid and altitude of the orienting point.

(b) Grid and altitude of the firing unit.

(c) Maximum ordinate (to the nearest meter) from the appropriate TFT.

Note. When determining the maximum ordinate from BCS or from FADAC, subtract the battery altitude from the displayed value.

(d) Quadrant elevation to be fired.

Note. If available, angle of fall from the appropriate TFT, table G, column 8, can be substituted for quadrant elevation. This may provide a higher probability of first-round detection.

(e) Time of flight.

(f) Target number.

c. Altitude Report. When a high-burst registration is being conducted with the AN/MPQ-4 radar, the command **REPORT ALTITUDE** is sent after the orienting data have been transmitted. The radar operator determines and reports the minimum altitude the radar can use. The orienting point altitude must be 2 PEHB above the ground altitude of the orienting point. If the altitude sent by radar is not 2 PEHB above the ground, the FDC raises the orienting point to the required altitude by applying the amount of 2 PEHB to the radar-reported altitude. The FDC then announces the new altitude to the radar operator.

d. Report Order. Regardless of the radar used, the report order **REPORT WHEN READY TO OBSERVE** must be included.

Note. See examples in figures 12-23 and 12-24 for sample mission formats (non-DMD).

12-26. DETERMINING FIRING DATA

Firing data for radar registrations are determined in the same manner as in HB/MPI registrations. Site for a registration conducted with the AN/MPQ-4 radar is determined after the altitude has been determined.

HIGH BURST (MEAN POINT OF IMPACT) REGISTRATION													
For use of this form, see FM 6-40; the proponent agency is US Army Training and Doctrine Command.													
COMPUTATION OF HB (MPI) LOCATION													
Message to Observers OBSERVE MPI REG FOR BEH 66, GRID 6336, REPORT ALTITUDE REPORT WHEN READY TO OBSERVE					Dis OI → O2	Az OI → O2							
						+		3200					
						Az O2 → OI							
Location of HB (MPI)					E	62	935	N	35	425	M	422	
COMPUTATION OF GFT SETTING													
Alt HB (MPI)	422	QE fired	324	Chart data to HB (MPI) location				Deflection	4830	Range	4830	DF corr	RG
-Alt Btry	348	-Site		GFT				Charge	4	Lot	XY		TOT
VI	74	Adj Elev	307	Range				4830	Elevation	307	Time	18.4	L6
												R12	6FT

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Figure 12-23. Example of an AN/MPQ-4 radar-observed MPI registration.

HIGH BURST (MEAN POINT OF IMPACT) REGISTRATION													
For use of this form, see FM 6-40; the proponent agency is US Army Training and Doctrine Command.													
COMPUTATION OF HB (MPI) LOCATION													
Message to Observers OBSERVE HB REG, FORT 2A16, AT GRID 6237, ALT 400. FROM: LOG 61321 32489, ALT 355 (ENCODED) 355, QE 289, TOT ACT 17 REPORT WHEN READY TO OBSERVE					Dis OI → O2	Az OI → O2							
						+		3200					
						Az O2 → OI							
Data Fired	Chg	DF	3003	FS	16.4	QE	287						
Observer Readings				Interior Angles									
Rd	OI	O2		OI on Left			OI on Right						
No	Az	VA	Az	Az OI → HB (MPI)			Az O2 → HB (MPI)						
①	085			+6400 if necessary			+6400 if necessary						
②	W			Total			Total						
③	W			-Az O2 → HB (MPI)			-Az OI → HB (MPI)						
④	W			APEX 4			APEX 4						
⑤	W			Az O2 → HB (MPI)									
⑥	W			+6400 if necessary									
Location of HB (MPI)				E	61	903	N	36	903	M	403		
COMPUTATION OF GFT SETTING													
Alt HB (MPI)	403	QE fired	287	Chart data to HB (MPI) location				Deflection	4480	Range	4480	DF corr	R15 (TOT)
-Alt Btry	355	-Site		GFT				Charge	4	Lot	XY		LS (OFT)
VI	48	Adj Elev	275	Range				4480	Elevation	275	Time	16.4	R20 (6FT)

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Figure 12-24. Example of an AN/TPQ-36/37 radar-observed high-burst registration.

Note. The AN/TPQ-37 radar section will request SHOT, will request SPLASH, and may make mission at their command.

12-27. FIRING THE HB/MPI REGISTRATION

a. AN/MPQ-4 Radar.

(1) The report for the AN/MPQ-4 radar includes the altitude of the orienting point. To reduce transmission time, the radar operator will queue the radar for each round fired. Therefore, the mission will be fired AMC, and SPLASH will be sent. ALTITUDE 450, AT MY COMMAND, REQUEST SPLASH, READY TO OBSERVE, OVER.

(2) When the radar reports READY TO OBSERVE and the firing piece reports READY, firing begins. If the first round is not visible in the telescope reticle and on the B-scope of the radar, the antenna is reoriented to the center of the burst, and the round is not used. If the first round burst more than 5 mils below the center of the reticle, the altitude must be increased and the round must not be used. After each round is fired, the radar operator reports OBSERVED or UNOBSERVED. If the report OBSERVED is followed by REQUEST SITE INCREASE, the burst is occurring too low. The quadrant elevation must be increased by the number of mils necessary to raise the burst approximately 2 PEHB. All of the previous rounds are discarded.

(3) After the rounds have been fired, the FDO has a number of options for determining the number of usable rounds he will need to determine the registration corrections.

(a) The FDO may allow the radar operator to determine which rounds are usable. The operator reports to the FDC the number of usable rounds and the grid and altitude of the mean burst location.

(b) The FDO may issue separate guidance on how the usable rounds will be determined.

(c) The FDO may request the grid and altitude of each round fired and determine the usable rounds himself.

b. AN/TPQ-36/37 Radar.

(1) The radar on-board computer uses the orienting data to check the trajectory and to determine whether it fits the radar's capabilities. Before firing, the radar operator determines whether the data are acceptable, marginal, or unacceptable. The radar section reports when they are ready to observe. AT MY COMMAND (REQUEST SPLASH), READY TO OBSERVE, OVER. Since the radar operator checks the acceptability of the orienting data before firing begins, all rounds fired should be acquired by radar. If the first round is not visible, an error has occurred. The radar operator informs the FDC that the round was unobserved. The FDC should verify firing data. If no errors are found and the next round is unobserved, the FDC should compute new orienting data and send it to the radar operator.

(2) If the grid and altitude of each round are reported, the FDO will determine the usable rounds.

12-28. DETERMINING THE MEAN BURST LOCATION

a. AN/MPQ-4 Radar.

(1) On completion of an HB registration, the radar operator will normally compute and report the grid and altitude of the MBL for the usable rounds. In an MPI registration, the radar operator computes and reports the grid of the MBL and the altitude of the selected datum plane.

(2) If the grid and altitude of each burst are reported, the FDO will determine the MBL by averaging the reported grids and altitudes of the usable rounds.

b. AN/TPQ-36/37 Radar. The radar operator reports the grid location and altitude of each burst. The FDO averages the grids and altitudes of the usable rounds to compute the mean burst location.

12-29. DETERMINING CHART DATA AND REGISTRATION CORRECTIONS

After the MBL and altitude have been determined, the procedures for computing chart data and registration corrections are the same as those for regular HB/MPI registrations.

Section V REGISTRATION CORRECTIONS

12-30. DESCRIPTION

a. Registration corrections consist of total range, fuze, and deflection corrections. The FDC computes these corrections by comparing the initial chart data to the adjusted data resulting from a registration. In situations in which a registration is not feasible, the corrections may be mathematically obtained through solution of a met (chap 10) and used as the basis for a GFT setting.

b. When properly applied, registration corrections make it possible to fire for effect on accurately located targets within transfer limits without an adjustment phase. Registration corrections also facilitate replot of targets located by adjustment of fire (chap 8).

c. The corrections determined by the registration are applied to the GFT. Registration corrections can be computed by and stored in the ballistic computers (BCS, TACFIRE, and FADAC). The computers automatically apply these corrections to firing data.

Note. The TI-59 hand-held calculator is not used to derive GFT settings. It can store/apply only one set of residuals per charge.

12-31. COMPUTATION OF TOTAL RANGE CORRECTION

a. When standard conditions exist, the elevation fired to achieve the chart range is

the elevation listed in the firing tables for that chart range. When nonstandard conditions exist, an adjusted elevation must be fired to achieve the same chart range.

b. The total range correction is the difference, in meters, between the initial chart range from battery center and the firing table range corresponding to the adjusted elevation. Determine the total range correction as follows:

(1) From the TFT or the GFT, determine the range to the nearest 10 meters corresponding to the adjusted elevation.

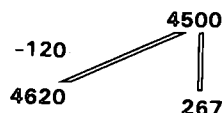
(2) Subtract the initial chart (or achieved) range from the range corresponding to the adjusted elevation. The result is the total range correction. The total range correction is always a signed value.

EXAMPLE

An M109A3 howitzer battery has registered using charge 4GB. The GFT setting has been corrected to compensate for adjusting piece displacement. The initial chart range was 4,620 meters, and the adjusted elevation was 267.

- *By use of the GFT, the range corresponding to the adjusted elevation of 267 is determined to be 4,500 meters.*
- *The initial chart range is subtracted from range corresponding to the adjusted elevation. The result is a total range correction of -120 meters (4,620 - 4,500 = -120 meters).*
- *The above procedures can be portrayed by use of a portion of the lazy Z.*

TOTAL RANGE CORRECTION



The difference between the initial chart range and the range corresponding to the adjusted elevation is -120. The total range correction is used in solving the concurrent met message.

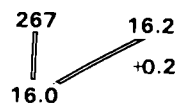
12-32. COMPUTATION OF TOTAL FUZE CORRECTION

a. The time portion of a registration results in an adjusted time (fuze setting). The time corresponding to the adjusted elevation is the time that must be compared to the actual adjusted time determined by firing. The difference between the time corresponding to the adjusted elevation and the adjusted time is the total fuze correction.

b. The total fuze correction is determined by subtracting the time corresponding to the adjusted elevation (or elevation plus CAS if the VI is greater than 100) from the adjusted time.

EXAMPLE:

Continuing the example above, the battery obtained an adjusted time of 16.2. The time corresponding to the adjusted elevation is 16.0. The time corresponding to the adjusted elevation is subtracted from the adjusted time to determine a total fuze correction ($16.2 - 16.0 = +0.2$). This procedure is portrayed by using the other half of the lazy Z.



TOTAL FUZE CORRECTION

12-33. COMPUTATION OF TOTAL DEFLECTION CORRECTION

a. The total deflection correction is the correction that must be added to the chart deflection to correct for the effects of nonstandard conditions. The total deflection correction is determined on DA Form 4757.

b. The total deflection correction is determined by subtracting the chart deflection from the adjusted deflection.

c. A GFT deflection correction is determined by subtracting the drift corresponding to the adjusted elevation from the total deflection correction. The GFT deflection correction remains the same for all elevations fired with the registered charge. The total deflection correction may change because of changes in drift depending on the elevation being fired.

EXAMPLE:

The battery's chart deflection is 3237, and adjusted deflection is 3255. The total deflection correction is L18. The drift corresponding to the adjusted elevation (267) (from the GFT) is L5. The GFT deflection correction is L13 (fig 12-25).

SECTION I. REGISTRATION COMPUTATION			
ACHIEVED RANGE		DEFLECTION CORRECTION	
1	CHART RANGE	7	CORRECTED DEFLECTION (REGISTRATION)
2	REGISTERING PIECE DISPLACEMENT (IF B-I)	8	REGISTERING PIECE DISPLACEMENT CORRECTION
3	ACHIEVED RANGE (1 + 2)	9	ADJUSTED DEFLECTION (7 + 8)
REGISTERING PIECE DISPLACEMENT CORRECTION		10	CHART DEFLECTION
4	LATERAL DISPLACEMENT (L-R)	11	TOTAL DEFLECTION CORRECTION (9 + 10) (L-R)
5	ACHIEVED RANGE (3)	12	DRIFT CORRECTION (- ADJUSTED ELEVATION) (L)
CORRECTION			

Figure 12-25. Deflection correction.

12-34. REGISTRATION TRANSFER LIMITS

The corrections determined from a registration are valid only within certain range and deflection limits. The registration corrections for nonstandard conditions are valid only when firing toward the registration point. For example, when firing on a different azimuth, the wind will not affect the round in the same manner as it did along the azimuth to the registration point. Registration corrections are valid only for the position from which the registration was fired (except for offset registrations).

a. Range Transfer Limits.

(1) **One-plot GFT setting.** The range limits for a one-plot GFT setting are shown on the graphical firing table. As long as the chart range of the registration point is between the leftmost and the rightmost met check gage points, the target is within the range transfer limits. The charge 4 GFT range limits are from range corresponding to elevation 150 (the first red-numbered elevation) to elevation 630 (the last red number on the elevation scale).

(2) **Two-plot GFT setting.** The range limits for a two-plot GFT setting are between the two ranges used to apply the GFT settings. This type of GFT setting begins to be invalid outside these two ranges.

(3) **Multiplot GFT setting.** The range limits for a multiplot GFT setting are eliminated when three or more sets of corrections are available for the same charge. When using the multiplot GFT setting, there are no range transfer limits.

b. Deflection Transfer Limits.

(1) The registration corrections are valid only within certain deflection transfer limits.

(2) When the chart range to a target is 10,000 meters or less, the deflection corrections are valid within an area 400 mils left and 400 mils right of a line between the battery and the registration point (mean burst location) (fig 12-26).

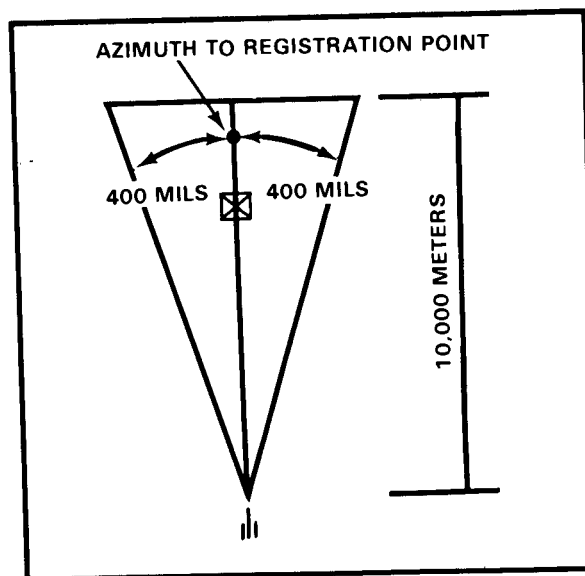


Figure 12-26. Registration transfer limits—10,000 meters or less.

(3) When the chart range to a target is greater than 10,000 meters, the registration corrections are valid within an area 4,000 meters left and 4,000 meters right of a line drawn between the battery and the registration point (mean burst location) (fig 12-27).

(4) Registration corrections may be determined throughout the entire 6,400 mils around the battery by using the eight-direction met technique.

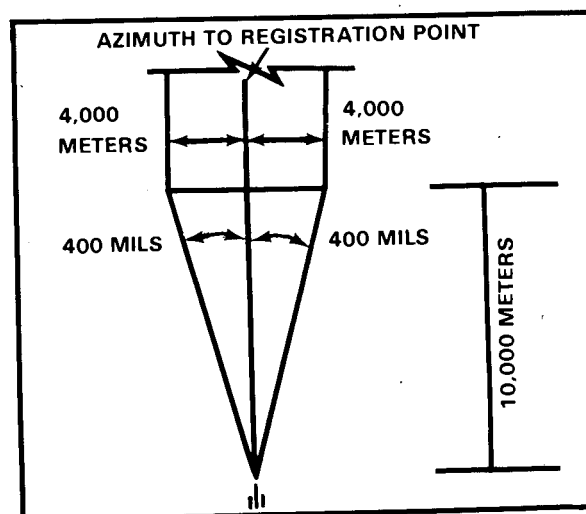


Figure 12-27. Registration transfer limits—greater than 10,000 meters.



CHAPTER 13

SPECIAL CORRECTIONS
AND SPECIAL SITUATIONS

To enhance survivability on the battlefield, a unit must take maximum advantage of the natural cover and concealment offered by the terrain and vegetation. When a unit is so positioned, corrections are required to obtain an acceptable burst pattern (sheaf) in the target area. These corrections, known as hasty corrections and special corrections, compensate for the differences in muzzle velocities between platoons and for the positioning of the weapons.

Survivability considerations require the occupation of positions in excess of 400 by 200 meters. Terrain gun position corrections do not allow for the occupation of battery positions in excess of 400 by 200 meters without sacrificing effectiveness in the target area. Therefore, terrain gun position corrections have extremely limited use

on the battlefield. Applying special corrections to a mission satisfies the requirement to place effective fires on the target without limiting the size of the battery position.

There are certain types of missions the FDC must be prepared to conduct that require special attention. These situations require special processing and are discussed in this chapter. These types of missions include the following:

- Attacking large targets.
- Delivering final protective fires.
- Answering fire requests from an air observer.
- Talking an untrained observer through a fire mission.
- Firing across grid zones.
- Using high-angle fire.

Section I.

BASIC CORRECTION DATA

13-1. PIECE DISPLACEMENT

a. Manual procedures for determining special corrections require that the relative position of pieces in the battery area be known (piece displacement). The FDC locates each weapon in the firing unit by use of the information provided by the advance party. Piece displacement is the number of meters that the piece is displaced forward or back

and right or left of the geographical battery center grid. It is measured on a line parallel to (forward/back) and perpendicular to (right/left) the azimuth of lay.

b. Piece displacement can be determined by estimation/pacing, hasty traverse, or survey. Usually, estimation and pacing are not accurate enough for the large distances encountered at battery positions. The hasty

traverse technique is a quick, accurate means of determining piece displacement by use of the M10/M17 plotting board. The survey technique provides grid coordinates for each weapon location.

13-2. ESTIMATION/PACING

a. Estimation is the least desirable method. Using this method, the battery commander or executive officer estimates the displacement of the pieces from the GBC, parallel and perpendicular to the azimuth of lay.

b. The pacing method provides fair accuracy in small open areas, but it is time consuming. Using this method, the battery commander or executive officer determines piece displacement by pacing from the GBC, parallel and perpendicular to the azimuth of lay.

13-3. HASTY TRAVERSE

The hasty traverse method is a rapid and accurate way to determine piece displacement. It is a graphic solution for piece displacement that uses the M10/M17 plotting board. The advance party provides the FDC with initial lay deflection and distance to the geographical battery center (GBC) and to each gun position.

13-4. SURVEY

Survey (grid and altitude) to each gun position, provided by field artillery survey crews, is the most accurate method. Piece displacement is computed by determining the difference between the grid coordinates from the GBC to each weapon position.

13-5. BALLISTIC COMPUTERS

The BCS does not consider piece displacement in firing data computation. It locates each weapon by grid coordinates and uses this information when it computes individual trajectories. The FADAC accounts for individual grid locations for each firing unit.

13-6. DESCRIPTION OF THE M10/M17 PLOTTING BOARD

The M10/M17 plotting board is used to compute special corrections. The plotting board consists of three basic parts.

a. Gridded Base. The gridded base (fig 13-1) normally represents the target area. The small red squares may be assigned any value depending on the intended use.

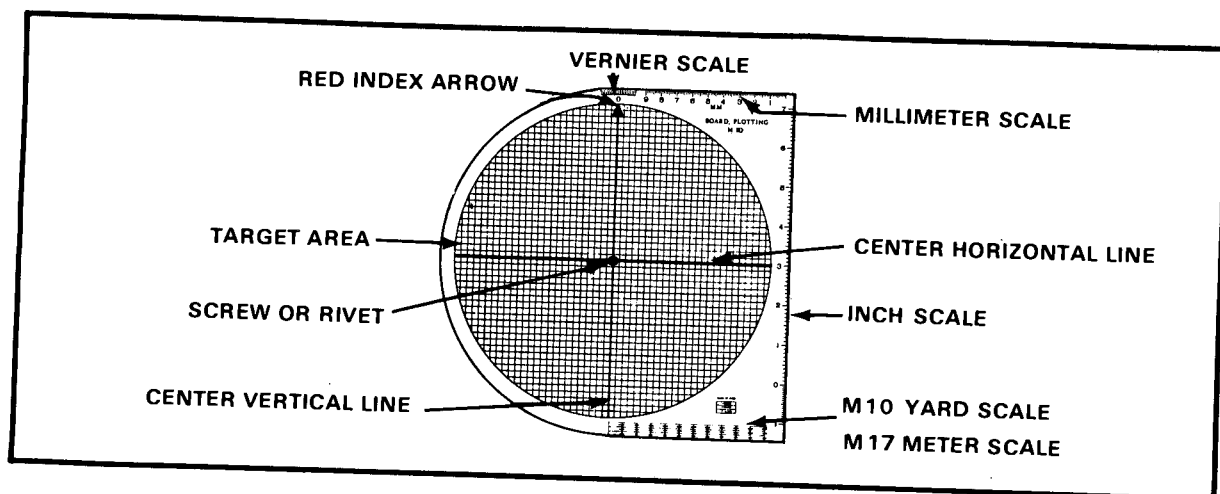


Figure 13-1. Gridded base.

Normally the following values, in meters, are used:

Special corrections	10
Emergency FDC	20
Laser hasty adjustment	200

The red arrow on the base represents the direction of fire. The center vertical line is a reference line used to measure lateral corrections. The center horizontal line is a reference line used to measure range corrections. Although it is not normally used, the vernier scale allows the visual interpolation of azimuth or deflection to the nearest mil. Other scales on the base are a millimeter scale (top) and an inch scale (right side). On the bottom of the base there are scales for measuring distances on maps. The scale on the M17 is in meters, and the scale on the M10 is in yards. The screw or rivet is used to hold the clear plastic disk to the base and may be used to represent one of the following:

- (1) Geographical battery center.
- (2) Target.
- (3) Observer location.
- (4) Location of the last burst.

b. Clear Plastic Disk. The clear plastic disk (fig 13-2) normally represents the battery position and has three scales around the outside edge.

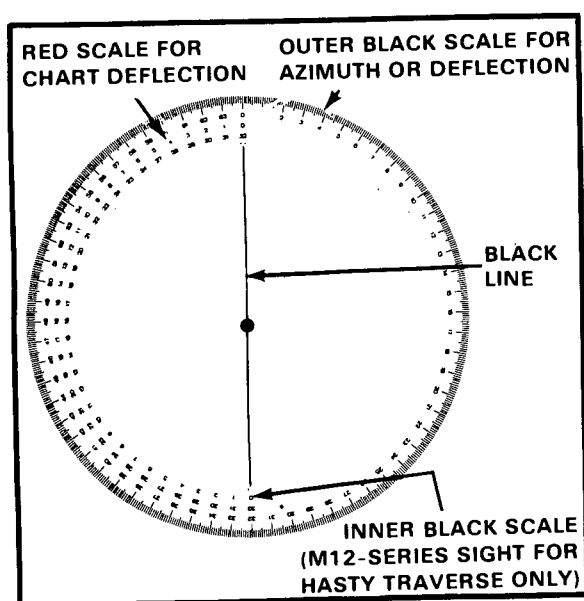


Figure 13-2. Clear plastic disk.

(1) The outer black scale is used for azimuths or initial lay deflections. It is graduated every 10 mils and numbered every 100 mils from 0 to 6300.

(2) The red scale is a chart deflection scale.

(3) The inner black scale is used primarily for the M12-series sight for hasty traverse.

13-7. PREPARING THE M10/M17 PLOTTING BOARD

a. General. Prepare the M10/M17 plotting board for the manual solution of special corrections in the following manner:

(1) Disassemble the plotting board by removing the clear plastic disk from the gridded base.

(2) To prepare the clear plastic disk for the M100-series sight deflection, extend the red deflection scale by crossing out the red numbers 1, 2, 3, 4, and 5 after number 32 and numbering from 33 to 63 (fig 13-3).

(3) To prepare the M12-series sight, extend the red deflection scale by numbering from 6 to 31 after the red numbers 1, 2, 3, 4, and 5.

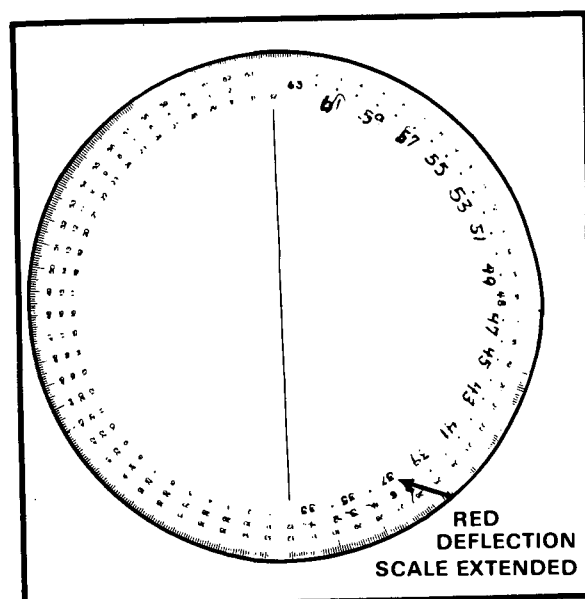


Figure 13-3. Preparing the disk.

(4) Reassemble the plotting board.

(5) To describe targets on the plotting board for the M100- or M12-series sight, construct an azimuth index.

(a) Orient the 3200 (outer black scale) over the red index arrow.

(b) Opposite the azimuth of lay (outer black scale), mark an azimuth index on the base. The relationship between azimuth and deflection has now been established. To set off an azimuth, turn the azimuth on the outer black scale opposite the azimuth index.

(6) The plotting board is now ready for use in special corrections.

b. Plotting Hasty Traverse Data (M100-Series Sight). Apply hasty traverse data to the M10/M17 plotting board in the following manner:

(1) **Plotting the aiming circle location.** To plot the aiming circle (AC) location (fig 13-4), place the initial deflection from the AC to the GBC over the red index

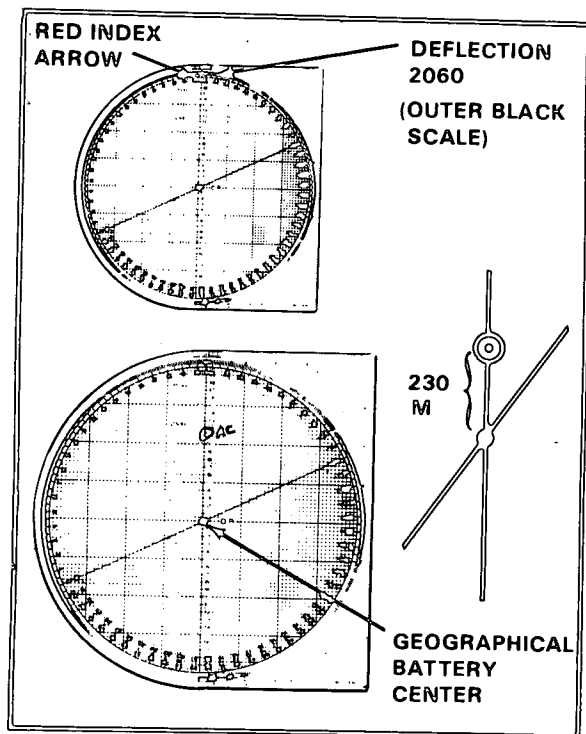


Figure 13-4. Plotting the aiming circle location—hasty traverse (M100-series sight).

arrow. Use the outer black scale (0 to 6300). Measure the distance from the GBC to the AC along the center vertical line from the center rivet toward the red index arrow. Place a dot there, circle it, and label it AC.

(2) **Plotting the weapon location.** To plot the weapon location (fig 13-5), place the initial lay deflection from the AC to the gun position (outer black scale) over the red index arrow. Measure the distance down from the AC on a line parallel to the center vertical line. Place a dot there and circle it. Label the dot to correspond to the weapon number. Use this procedure for all other weapons.

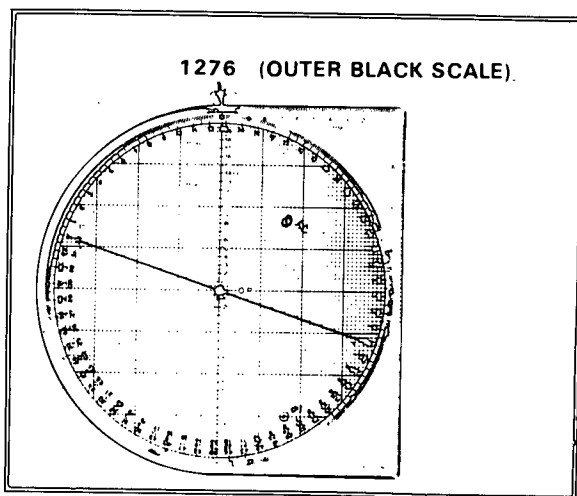


Figure 13-5. Plotting the weapon locations—hasty traverse (M100-series sight).

(3) **Plotting the platoon center location.** To plot the platoon center location, identify the dots representing the two guns of a platoon. Using a straightedge, draw a light line between the two dots. Place a dot at the midpoint of the line. This dot represents the platoon center. Label the dot with the appropriate platoon designation.

***(4) Determining and recording piece displacement on the computer's checklist.** To determine piece displacement (fig 13-6), rotate the 3200 (inner red scale) over the red index arrow, and read piece displacement left/right and forward/back of the GBC, represented by the center rivet. Record the piece displacement on DA Form 5338-R (Computer Checklist) (fig 13-7 and app J).

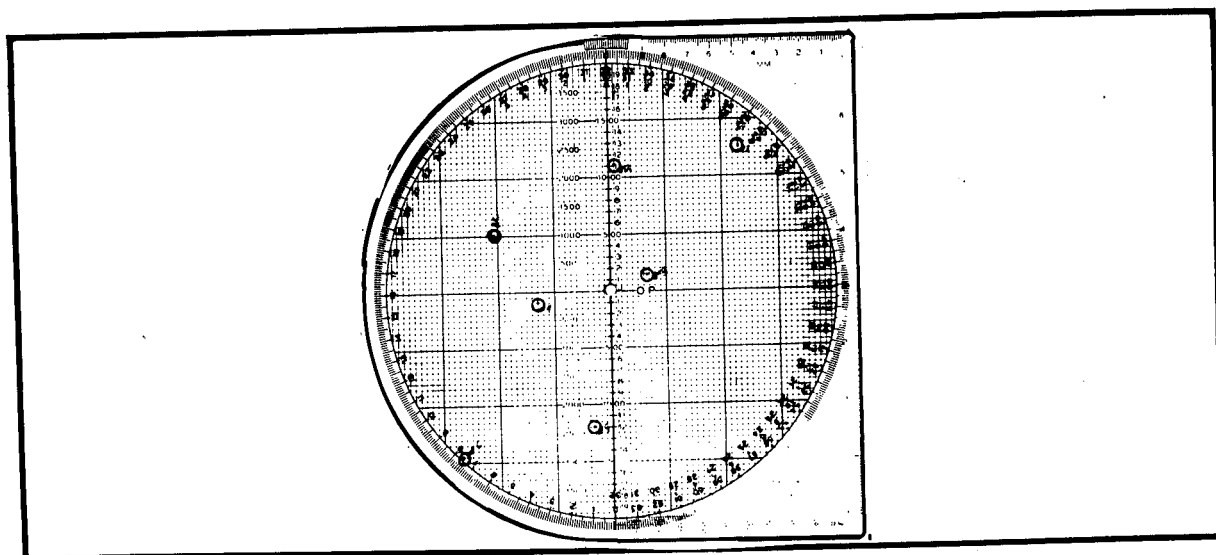


Figure 13-6. Determining piece displacement.

FIRE ORDER STANDARDS			ADJUST FIRE	FIRE FOR EFFECT	PIECE DISPLACEMENT DATA			
1. UNIT TO FIRE			BTRY	BTRY	GUN NUMBER	GRID	DISPLACEMENT	
2. ADJUSTING ELEMENT/METHOD OF FIRE OF ADJUSTING ELEMENT			BCU Select	FFE			LATERAL	RANGE
3. BASIS FOR CORRECTION			BCU	BCU	1		R230	-250
4. DISTRIBUTION			100M TGT RADUS	100M TGT RADUS	2		R10	-220
5. PROJECTILE			HE	DPICM	3		R65	-25
6. AMMUNITION LOT/CHARGE			BCU SELECT	BCU SELECT	4		L130	+20
7. FUZE			PD	TIME	5		L35	+240
8. NUMBER OF ROUNDS			ODPICM	0	6		L270	+295
9. RANGE SPREAD, LATERAL SPREAD, ZONE OR SWEEP					AIMING CIRCLE			
10. TIME OF OPENING FIRE			When Ready	When Ready	PRIORITY TARGET INFORMATION FINAL PROTECTIVE FIRE/ COPPERHEAD			
11. TARGET NUMBER			Next Assigned	Next Assigned				
FIRE COMMAND STANDARDS			ADJUST FIRE	FIRE FOR EFFECT	GRID		TARGET NUMBER	
12. WARNING ORDER			0	BTRY 0	6234 3826 390		AA7054	
13. PIECE TO FOLLOW/PIECE TO FIRE/METHOD OF FIRE								
14. SPECIAL INSTRUCTIONS			HE	DPICM				
15. PROJECTILE			XY	XY				
AMMUNITION LOT					25. FIRE PLAN			
BATTERY AMMUNITION COUNT	BATTERY DATA	GRID/ALTITUDE	AZIMUTH	CALL SIGN	DOG			
HE 400	A	61321 32484 333	6350	G12	KNOWN POINT TARGET	LOCATION	TIME ON TARGET	UNIT OF FIRE
WB 50	B	60858 32640 333	6350	J27				
GB 450	C	60478 32838 348	6350	V54	AA7052	5950 3700 320	1305	LEFT PLT
PD 430					AA7054	6234 3826 390	1310	BTRY
T1 20					AA7059	6258 3835 363	1312	BTRY
21. HIGH EXPLOSIVE								
GFTA, Chg 4, Lot XY, RG 3730, EL 225 + 1128								
GFTA, Chg 4, Lot XY, RG 5140, EL 335 + 1189								
GFTA, Chg 4, Lot XY, RG 5580, EL 374, T1 210, GFT B4								

Figure 13-7. Computer checklist—piece displacement data.

EXAMPLE:

The following data are provided to demonstrate plotting hasty traverse on the M10/M17 plotting board and to determine piece displacement for a unit with the M100-series sight.

Battery B's advance party has completed its preparation of a new position. The advance party provides the following hasty traverse data to the fire direction center:

FROM AC TO:	DEFLECTION	DISTANCE
Geographical battery center	2060	230
Gun 1	1276	465
Gun 2	1092	250
Gun 3	1881	280
Gun 4	2628	145
Gun 5	2721	385
Gun 6	3361	400

Azimuth of lay 6350

The FDC plots the data on the M10/M17 plotting board and determines the following piece and platoon displacement data:

WEAPON	RIGHT/ LEFT	FORWARD/ BACK	PLATOON	RIGHT/ LEFT	FORWARD/ BACK
1	230R	250F	right	R120	F235
2	10R	220F			
3	65R	25F	center	L35	F5
4	130L	20B			
5	35L	240B	left	L150	B265
6	270L	295B			

c. Plotting Hasty Traverse Data (M12-Series Sight). Apply hasty traverse data to the M10/M17 plotting board in the following manner:

(1) Plotting the aiming circle location. To plot the AC location (fig 13-8), place the initial lay deflection (outer black scale) from the AC to the GBC over the red index arrow. Measure the distance from the GBC to the AC along the center vertical line toward the red index arrow. Place a dot there and circle it. Label the dot AC.

(2) Plotting the weapon location. To plot the weapon location (fig 13-9), place the initial lay deflection over the red index arrow.

(a) When the weapon is to the right of the AC in relation to the 0 to 3200 line, use the outer black scale.

(b) When the weapon is to the left of the AC, use the inner black scale.

(c) When the deflection from the AC to any weapon is exactly 3200, the following apply:

- If the weapon is behind the AC, use the outer black scale.
- If the weapon is forward of the AC, use the inner black scale.

(d) Measure the distance down from the AC on a line parallel to the center vertical

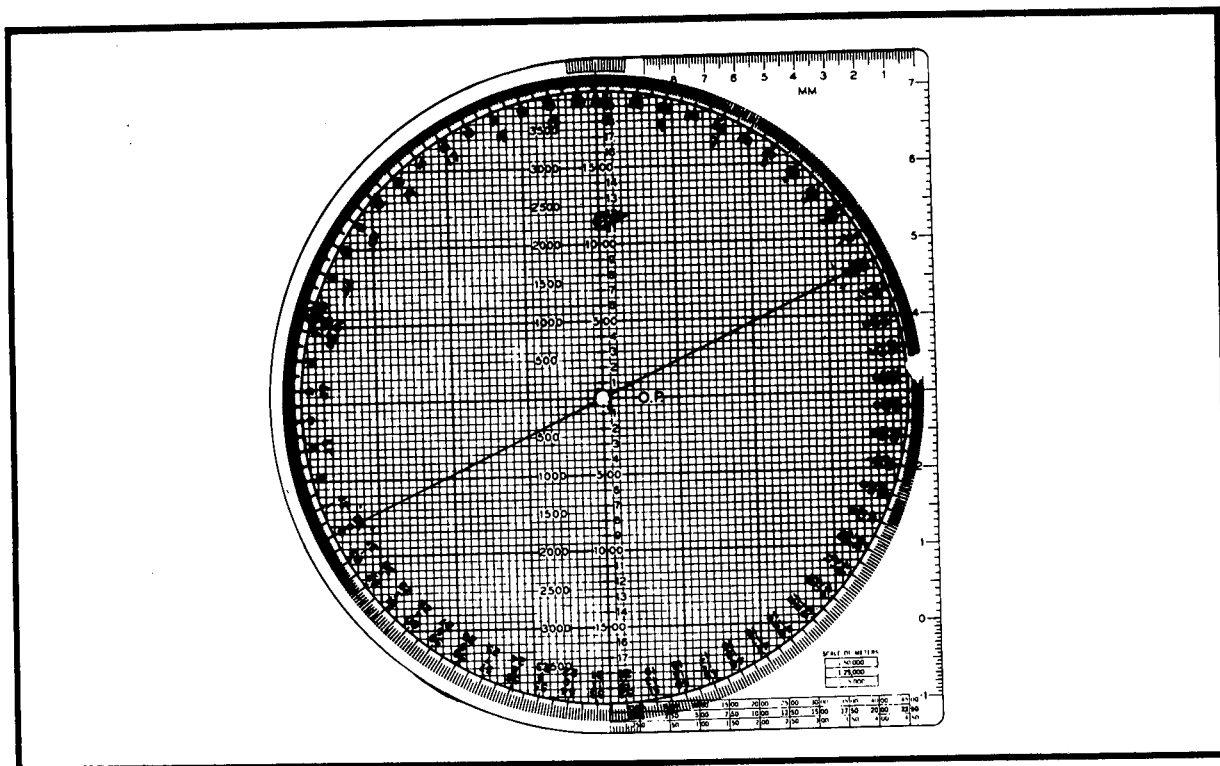


Figure 13-8. Plotting the aiming circle location—hasty traverse (M12-series sight).

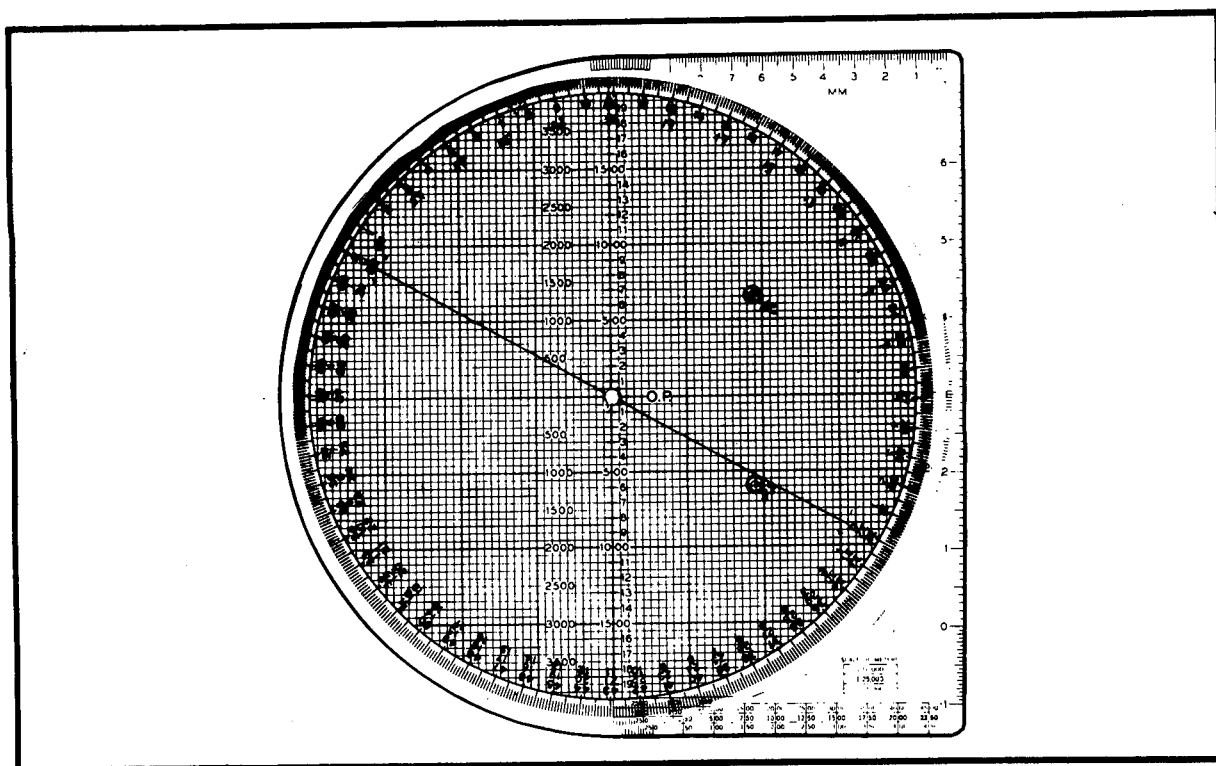


Figure 13-9. Plotting the weapon location—hasty traverse (M12-series sight).

line. Place a dot there and circle it. Label the dot to correspond to the weapon number. Use this procedure for all other weapons.

(3) Applying the deflection index.

Orient the 3200 on the outer black scale over the red index arrow. Without moving the clear plastic disk, place a mark on the base corresponding to the common deflection (2400 or 2800, inner red scale). Label it the deflection index.

(4) Determining and recording piece displacement. With the 3200 (outer black scale) over the red index arrow, read piece displacement left/right and forward/back of the GBC represented by the center rivet (fig 13-10).

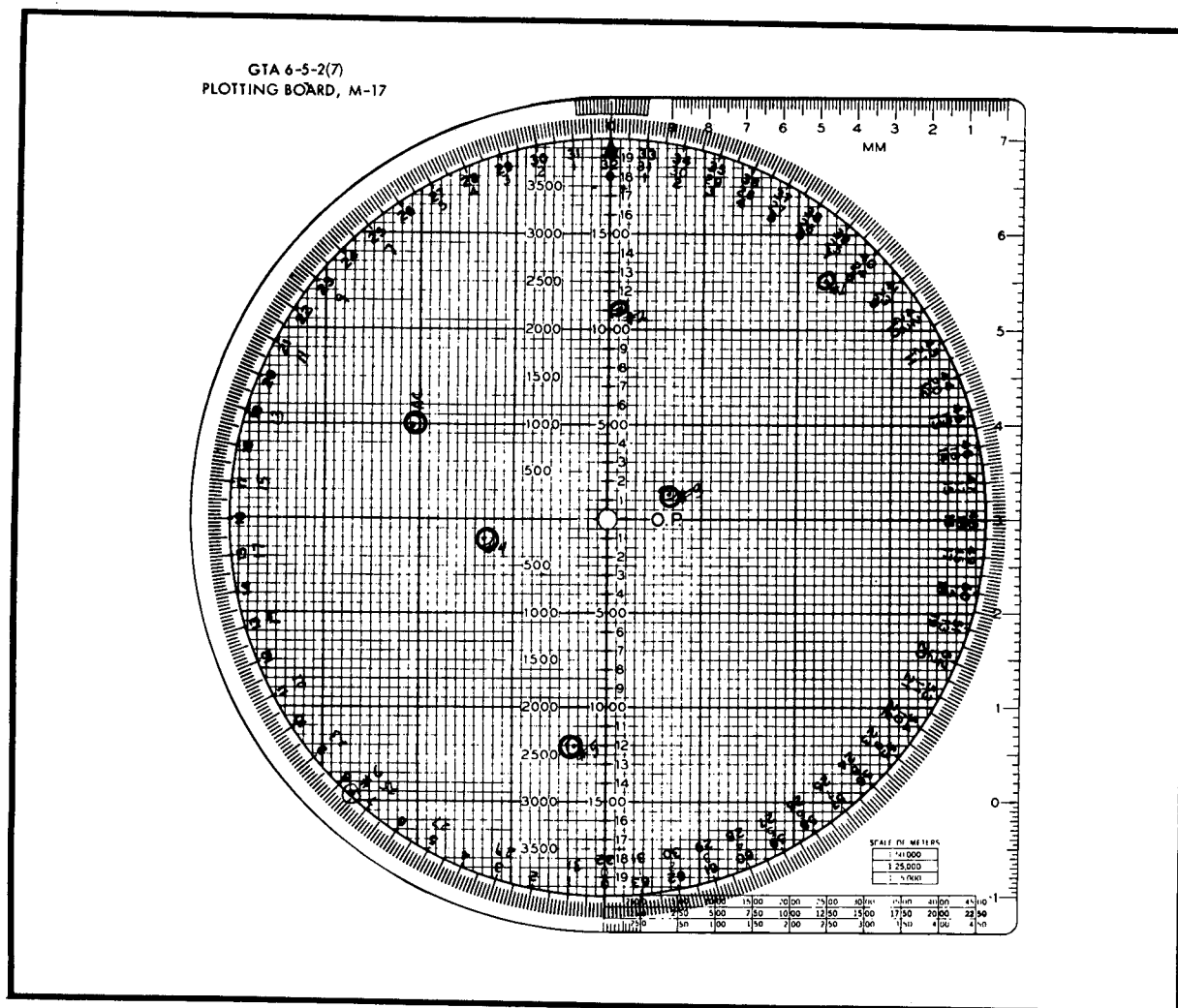


Figure 13-10. Determining and recording piece displacement—hasty traverse (M12-series sight).

EXAMPLE:

The following situation demonstrates hasty traverse determination with the M12-series sight. Battery C's advance party has completed its preparation of a new position. The advance party provides the following hasty traverse data to the fire direction center.

<i>FROM AC TO:</i>	<i>DEFLECTION</i>	<i>DISTANCE</i>
<i>Geographical battery center</i>	<i>2060</i>	<i>230</i>
<i>Gun 1</i>	<i>1276</i>	<i>465</i>
<i>Gun 2</i>	<i>1090</i>	<i>250</i>
<i>Gun 3</i>	<i>1881</i>	<i>280</i>
<i>Gun 4</i>	<i>2629</i>	<i>140</i>
<i>Gun 5</i>	<i>2725</i>	<i>385</i>
<i>Gun 6 (Gun is left of aiming circle)</i>	<i>0169</i>	<i>400</i>
<i>Common deflection 2400</i>		

The FDC plots the data on the M10/M17 plotting board and makes a deflection index on the base opposite 2400 (inner red scale) and determines the following piece and platoon displacement data:

<i>WEAPON</i>	<i>RIGHT/ LEFT</i>	<i>FORWARD/ BACK</i>	<i>PLATOON</i>	<i>RIGHT/ LEFT</i>	<i>FORWARD/ BACK</i>
<i>1</i>	<i>230R</i>	<i>250F</i>	<i>right</i>	<i>R120</i>	<i>F235</i>
<i>2</i>	<i>10R</i>	<i>220F</i>			
<i>3</i>	<i>65R</i>	<i>25F</i>	<i>center</i>	<i>L35</i>	<i>F5</i>
<i>4</i>	<i>130L</i>	<i>20B</i>			
<i>5</i>	<i>35L</i>	<i>240B</i>	<i>left</i>	<i>L150</i>	<i>B265</i>
<i>6</i>	<i>270L</i>	<i>295B</i>			

d. Plotting Hasty Traverse by Use of Two Aiming Circles. Two ACs may be required to lay the battery when widely dispersed position areas are being occupied. One of two situations must exist before hasty traverse with two ACs can be used.

(1) The geographical battery center is visible from both ACs. After plotting the first AC, as outlined in paragraph *b* or *c* above, use the same procedures to plot the second AC.

(2) The two ACs are visible to each other, but one AC does not have line of sight with the geographical battery center.

(a) Plot the AC that has line of sight with the GBC as described in paragraphs *b* and *c* above.

(b) To plot the second AC, rotate the deflection from AC 1 to AC 2 over the red index arrow.

(c) Mark off the distance down from AC 1, parallel to the center vertical line. Place a dot there, circle it, and label it AC 2. Each weapon will then be plotted on the plotting board from the AC from which it was laid.

e. Plotting Estimated/Paced Data (All Sights).

(1) The advance party gives the FDC piece location data based on estimation/pacing in relation to the azimuth of lay.

(2) The FDC applies the data to the M10/M17 plotting board by use of the following steps:

(a) Place 3200 (inner red scale) over the red index arrow. This aligns the common deflection with the deflection index.

(b) Using the center rivet as the GBC, place off the estimated/paced displacement for each weapon. Place a dot at the corresponding location, and label it with the appropriate weapon number.

(c) Without moving the clear plastic disk, make the azimuth index on the base

correspond to the azimuth of lay read on the outer black scale.

EXAMPLE:

Battery B's advance party has completed its preparation of a new position. The advance party provides the following estimated/paced data to the fire direction center. Data provided are from the geographical battery center.

WEAPON	RIGHT/ LEFT	FORWARD/ BACK
1	R230	F250
2	R10	F220
3	R65	F25
4	L130	B20
5	L35	B240
6	L270	B295

f. Plotting Survey Data (All Sights).

(1) The field artillery survey party gives the FDC the survey, grid, and altitude of each weapon and the altitude of the geographical battery center.

(2) The FDC applies the data to the M10/M17 plotting board.

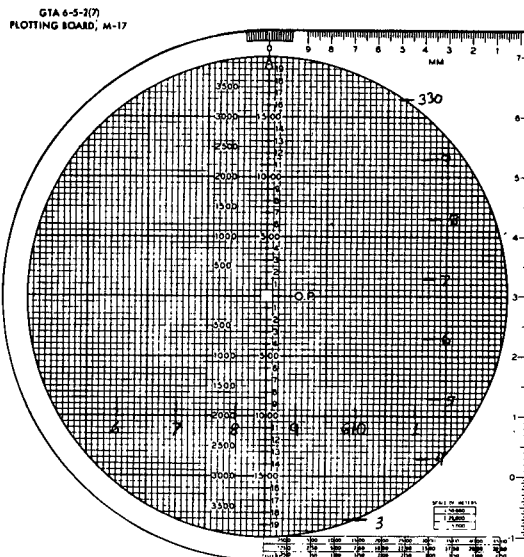
EXAMPLE:

Remove the clear plastic disk, and construct the grid reference system on the base of the M10/M17 plotting board so that the grid coordinates to the GBC will correspond to the center rivet to the nearest 10 meters.

GUN POSITION	GRID COORDINATES	ALTITUDE
1	61082 32918	353
2	60861 32882	355
3	60920 32689	354
4	60728 32637	349
5	60839 32417	351
6	60604 32354	350

Azimuth of lay 6350

STEP 1. Prepare the M10/M17 base by use of a grid reference system.



- STEP 2.** Replace the clear plastic disk, and construct the azimuth index.
- STEP 3.** Orient the clear plastic disk to grid north.
- STEP 4.** Plot and label the weapon locations on the clear plastic disk.
- STEP 5.** Determine platoon centers (example uses right platoon only).

Easting gun 1	61082
Easting gun 2	+ 60861
Total value	<u>121943</u>

Total value divided by 2 equals platoon easting.

$121943 \div 2 = 60971.5 \approx 60972$

Northing gun 1	32918
----------------	-------

Northing gun 2	+ 32882
----------------	---------

Total value	<u>65800</u>
-------------	--------------

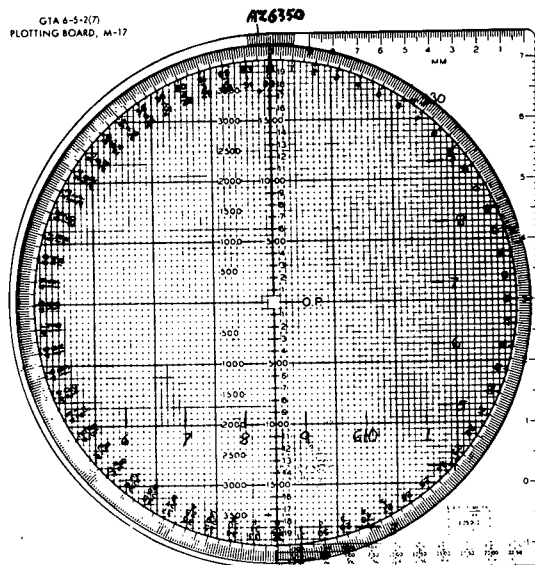
Total value divided by 2 equals platoon northing.

$65800 \div 2 = 32900$

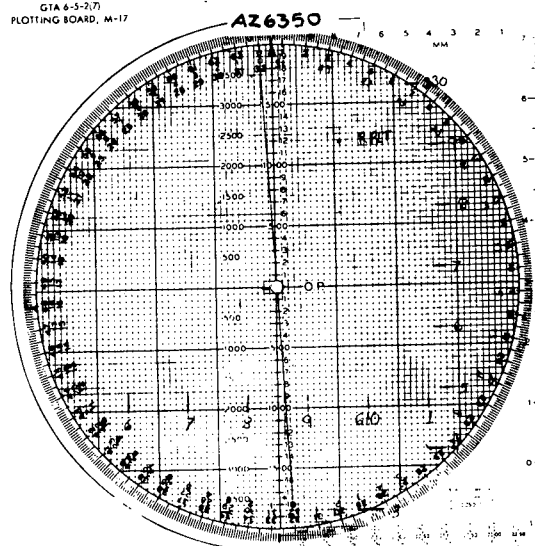
Right platoon center = grid 65800 32900

Platoon altitude = $353 + 355 = 708 \div 2 = 354$

GTA 6-5-2(7)
PLOTING BOARD, M-17



GTA 6-5-2(7)
PLOTING BOARD, M-17



Section II POSITION CORRECTIONS

13-8. TYPES OF POSITION CORRECTIONS

Position corrections are applied to fire-for-effect data to modify the sheaf. This ensures the fire-for-effect burst will have maximum effect on the target. The two types of position corrections are *special corrections* and *hasty corrections*.

a. Fire-for-Effect Mission. For a fire-for-effect mission, special corrections are determined and applied on a mission-by-mission basis depending on the time available, target size, target shape, friendly troop locations, and accuracy of the target location. Special corrections are categorized by the type of sheaf applied to the fire-for-effect data.

(1) **Parallel sheaf.** All guns fire the same time, deflection, and quadrant. This type of sheaf is the least effective, but it is the most responsive.

(2) **Converged sheaf.** Each gun fires a unique time, deflection, and quadrant that cause all fire-for-effect rounds to impact at the same point. This special correction is used with point targets.

(3) **Special sheaf.** Each gun fires at separate aiming points on the target for maximum munition effects. The special sheaf is the preferred sheaf for attacking circular targets that have a radius greater than 100 meters or that have specific shapes or attitudes.

b. Adjust Fire Mission. For an adjust fire mission, hasty corrections are applied to platoon firing data by use of the hasty correction tables (app A).

Note. If a firing unit is unable to effectively attack a target because of target posture, target size, munition effects, etc., other methods of attack should be considered. Other methods are discussed in section III.

13-9. REGISTRATION/ SPECIAL CORRECTION WORK SHEET

DA Form 4757 is provided for determining and recording computations and data for registrations, GFT settings, and special corrections.

13-10. REGISTRATION PORTION

Section I of DA Form 4757 is used to compute registration corrections for a firing unit (fig 13-11). It is designed to compute achieved range, the displacement correction, and the deflection correction for the registering piece when the piece is not over the geographical battery center. A portion is provided to record GFT settings and computer and hand-held calculator registration residuals.

a. Achieved Range. Use the achieved range portion in the following manner:

(1) Enter in **1** the chart range to the registration point (to the nearest 10 meters).

(2) Enter in **2** the registering piece displacement (to the nearest 10 meters) and the appropriate sign (forward [-] or back [+]).

(3) Algebraically add **1** and **2** to determine the registration achieved range (to the nearest 10 meters), and enter it in **3**.

b. Registering Piece Displacement Correction. Use the registering piece displacement correction portion of the form in the following manner:

(1) Enter in **4** the registering piece lateral piece displacement (to the nearest 5 meters) and the appropriate letter (L for left, R for right).

(2) Enter in **5** the value determined from **3** (to the nearest 10 meters).

(3) Divide **4** by **5** to determine the registering piece displacement correction (left or right) (to the nearest mil), and enter it in **6**.

c. Deflection Correction. Use the deflection correction portion of the form in the following manner:

(1) Enter in **7** the registration corrected deflection (to the nearest mil).

(2) Enter in **8** the registering piece displacement correction from **6** (to the nearest mil).

(3) Algebraically add **7** and **8** to determine the adjusted deflection (to the nearest mil), and enter it in **9**.

(4) Enter in 10 the chart deflection (to the nearest mil).

(5) Subtract 10 from 9 and enter the total deflection correction (to the nearest mil) and the appropriate sign in 11

(6) Enter in 12 the value of the drift correction corresponding to the adjusted elevation (to the nearest mil). Drift correction is always a left (add) value.

(7) Determine the GFT deflection (to the nearest mil) by subtracting 12 from 11, and enter it in 13

d. Lazy Z. After applying the corrections for achieved range, registering piece displacement, and deflection, use the space in the REMARKS block at the bottom of the form to determine the lazy Z for the registration.

e. GFT Setting. To determine a GFT setting when the registering piece is not over the geographical battery center, use—

(1) The computed achieved range instead of the initial chart range.

(2) The registering piece displacement correction to determine the adjusted registration GFT deflection correction.

(3) The adjusted GFT deflection correction.

EXAMPLE:

Battery A has just completed registering with gun 4. The piece displacement for gun 4 is L130, B20. Chart range to the target is 5,070 meters, and chart deflection is 3304. The uncorrected GFT setting from the registration is GFT A: Chg 4GB, Lot XY, Rg 5070, El 324; GFT Df Corr: R2, Tot Df Corr: L5. The corrected GFT setting accounting for registering piece displacement is computed on DA Form 4757 (fig 13-11).

REGISTRATION/SPECIAL CORRECTION WORK SHEET									
For use of this form see FM 6-40; proponent agency is TRADOC									
SECTION I. REGISTRATION COMPUTATION									
ACHIEVED RANGE					DEFLECTION CORRECTION				
1	CHART RANGE	<u>5070</u> (10 METERS)			7	CORRECTED DEFLECTION (REGISTRATION)	<u>3307</u> (1 MIL)		
2	REGISTERING PIECE DISPLACEMENT (IF B-1)	<u>+20</u> (10 METERS)			8	REGISTERING PIECE DISPLACEMENT CORRECTION	<u>+26</u> (1 MIL)		
3	ACHIEVED RANGE (1) + (2)	<u>5090</u> (10 METERS)			9	ADJUSTED DEFLECTION (7) + (8)	<u>3336</u> (1 MIL)		
REGISTERING PIECE DISPLACEMENT CORRECTION					10	CHART DEFLECTION	<u>3304</u> (1 MIL)		
4	LATERAL DISPLACEMENT (L R)	<u>L 130</u> (5 METERS)			11	TOTAL DEFLECTION CORRECTION (9) + (10) (L R)	<u>L 31</u> (1 MIL)		
5	ACHIEVED RANGE (3)	<u>5090</u> (10 METERS)			12	DRIFT CORRECTION (ADJUSTED ELEVATION) (L)	<u>L 7</u> (1 MIL)		
6	REGISTERING PIECE DISPLACEMENT CORRECTION (4) - (5) (L R)	<u>L 26</u> (1 MIL)			13	GRAPHICAL FIRING TABLE (GFT) DEFLECTION CORRECTION (11) + (12)	<u>L 24</u> (1 MIL)		
GFT SETTING (MANUAL METHOD)									
14	GFT <u>A</u>	CHARGE <u>4</u>	LOT <u>XY</u>	RANGE <u>5090</u>	ELEVATION <u>324</u>	TIME	TOTAL	GFT	
15	GFT	CHARGE	LOT	RANGE	ELEVATION	TIME	<u>L 31</u>	<u>L 24</u>	
16	GFT	CHARGE	LOT	RANGE	ELEVATION	TIME			
GFT SETTING (COMPUTER METHOD)									
17	BCS AMMUNITION AND FIRE UNIT REGISTRATION	RANGE	RANGE CORRECTION	TIME CORRECTION	DEFLECTION CORRECTION				
18	HAND-HELD CALCULATOR RESIDUALS	DEFLECTION CORRECTION	FUZE K	RANGE K					
19	FADAC RESIDUALS								

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Figure 13-11. Section I of DA Form 4757.

SECTION II. HASTY CORRECTIONS									
INITIAL CHART DATA		DEFLECTION		RANGE		TARGET		DATE TIME GROUP 05 1400 94	
PLATOON	POSITION LATERAL CORRECTION (LEFT - RIGHT)	HASTY POSITION DEFLECTION CORRECTION - (a)	PLATOON COMPARATIVE MUZZLE VELOCITY VARIATION	HASTY MUZZLE CORRECTION - (c)	POSITION RANGE CORRECTION FORWARD BACK - (e)	HASTY POSITION QUADRANT ELEVATION CORRECTION	TOTAL QUADRANT ELEVATION CORRECTION (d) + (f)	CORRECTED QUADRANT ELEVATION SITE FIRED ELEVATION	TIME TO FIRE ELEVATION GAGE LINE OVER (h) READ TIME
	a	b	c	d	e	f	g	h	i
	5 METERS	AS LISTED	0.1 METER PER SECOND	AS LISTED	5 METERS	AS LISTED	1 MIL	1 MIL	0.1
R	R120	L34	I1.0	-1	-235	-14	-15	216	12.3
C	L130	R8	0	0	5	0	0	231	13.5
L	L150	R42	D0.8	+1	+265	+15	+16	247	14.0

Figure 13-12. Section II of DA Form 4757.

13-11. HASTY CORRECTION PORTION

Use section II of DA Form 4757 to compute hasty corrections by platoon (fig 13-12). Enter the initial chart deflection, chart range, target number, and date-time group at the top of section II.

a. Deflection Corrections.

(1) A positive lateral correction is the number of meters left or right that each platoon center is from the GBC on the basis of the azimuth of lay. Determine this value by use of the M10/M17 plotting board, and enter it in column *a*.

(2) A hasty position deflection correction is the correction value applied to the fire-for-effect adjusted deflection. Determine this value by entering the hasty position deflection correction portion of the appropriate hasty special correction table. Enter the table with the initial range and initial platoon displacement (on the basis of the azimuth of lay) to the target. Extract the position deflection correction, and enter it in column *b*.

b. Quadrant Corrections.

(1) Enter in column *c* the platoon comparative muzzle velocity.

(2) Enter in column *d* the hasty MV correction factor extracted from the hasty MV correction portion of the appropriate hasty special correction table (app A). Enter the table with the platoon comparative MV and the initial range to the target.

(3) The position range correction is the number of meters (forward or back) from the platoon location to the platoon aiming point. Determine this value by use of the M10/M17 plotting board, and enter it in column *e*.

(4) Enter in column *f* the hasty position quadrant elevation correction extracted from the hasty position quadrant elevation correction portion of the appropriate hasty special correction table. Enter the table with the position range correction and the initial chart range.

(5) To determine the total quadrant elevation correction, add column *d* to column *f*. Enter the total in column *g*.

c. Determination of Time.

(1) Enter in column *h* the corrected quadrant minus the fired site.

(2) Determine the time to fire corresponding to column *h* from the appropriate gage line. Enter it in column *i*.

13-12. SPECIAL CORRECTION PORTION

Use section III of DA Form 4757 to compute special corrections by gun or by platoon (fig 13-13). Enter the initial chart deflection, chart range, target number, and date-time group at the top of section III.

a. Deflection Corrections.

(1) Determine the position lateral correction from the platoon position to the platoon aiming point by use of a properly oriented M10/M17 plotting board. Enter the correction in column *a*.

(2) Enter in column *b* the 100/R value determined at chart range to the target.

(3) Compute the position deflection applied to the initial deflection to fire by multiplying column *a* by column *b* and dividing by 100. Enter the value in column *c*.

b. Quadrant Corrections.

(1) Extract the platoon comparative MVV from the battery MV logbook and enter it in column *d*.

(2) Enter in column *e* the MV correction factor extracted from table F, column 10 or 11.

(3) Compute the range correction due to muzzle velocity in column *f* by multiplying column *d* by column *e*.

(4) Determine the position range correction from the platoon position to the platoon aiming point by use of a properly oriented M10/M17 plotting board. Enter the correction in column *g*.

(5) Determine the total range correction in column *h* by adding columns *f* and *g*.

(6) Determine the position quadrant elevation correction in column *i* by dividing the value in column *h* by the change in range per 1-mil change in elevation extracted from table F, column 5. Apply this value to the initial quadrant to fire.

SECTION III. SPECIAL CORRECTIONS												
INITIAL CHART DATA			DEFLECTION		RANGE		TARGET		DATE TIME GROUP			
PLATOON	GUN NUMBER	POSITION LATERAL CORRECTION (LEFT RIGHT)	100 R GRAPHICAL FIRING TABLE	POSITION DEFLECTION CORRECTION (LEFT RIGHT)	PLATOON COMPARATIVE VELOCITY ERROR (INCREASE DECREASE)	MUZZLE VELOCITY UNIT CORRECTION FACTOR (TABLE F APPROPRIATE FT)	MUZZLE VELOCITY RANGE CORRECTION	POSITION RANGE CORRECTION (FORWARD BACK)	TOTAL RANGE CORRECTION	POSITION QUADRANT ELEVATION CORRECTION (TABLE F APPROPRIATE FT)	CORRECTED RANGE	TIME (1) FIRE SETTING
		<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>f</i>	<i>g</i>	<i>h</i>	<i>i</i>	<i>j</i>	<i>k</i>
		5 METERS	1 MIL	1 MIL	0.1 METER PER SECOND	0.1 METER	1 METER	5 METERS	1 METER	1 MIL	10 METERS	0.1
R		L145	24	L35	11.0	-16.4	-16	-220	-236	-17	3990	13.9
C		R35	24	R8	0	0	0	-5	-5	0	4230	14.9
L		R180	24	R43	10.8	+20.9	+17	+250	+267	+19	4500	16.0

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Figure 13-13. Section III of DA Form 4757.

c. Determination of Time to Fire.

(1) Determine the corrected range in column *j* by adding the initial chart range to column *h* expressed to the nearest 10 meters.

(2) Determine the time to fire by placing the MHL over the value in column *j*. Read time from the appropriate gage line.

13-13. PARALLEL SHEAF

a. Fire for Effect. All guns fire the time, deflection, and quadrant computed by the FDC on the basis of the chart data determined from the GBC and the target center.

b. Adjust Fire. All guns fire the time, deflection, and quadrant determined by the adjustment when fire for effect was requested by the observer.

13-14. CONVERGED SHEAF

a. Fire-for-effect missions.

(1) Determine chart data (GBC to target center) to the target.

(2) Determine initial firing data (deflection and quadrant) on the basis of the chart data (fig 13-14).

Pct: Dtr		Dis		U/D		VA															
S/N		Dtr		U/D		+/-		U/D													
FIRE ORDER CONVERGED SHEAF, VT @ AMC																					
INITIAL FIRE COMMANDS		FC		MF		BTRY @		Dg		4230		Df Corr		0		Si		+9		HOD Corr	
Sp Instr		SPECIAL CORR, AMC		Sh		Lot		Chd		4		Fz VT		Ti		14.0		Df		(3094)	
MTO		G, VT @ AC 7834		T		PER		TF								in Eff		Ammo Exp			
Tgt		Location		Priority		Firing Unit															
Dtr, MF, Sh, Fz		Dov		Dg		HOD Corr		MF, Sh, Chd, Fz		FS Corr		Ti		Chart Df		Df Corr ()		Df Fired		Chart Dg	
								RPLT						3094						271	
								CPLT				14.0		3094						271	
								LPLT						3094						271	

Figure 13-14. Initial firing data.

(3). Use the registration/special correction work sheet to determine corrections to the initial deflection and quadrant and to determine the time to fire. Use these procedures for each platoon.

(a) *Deflection corrections.* Determine deflection corrections as follows:

- Orient the M10/M17 plotting board (fig 13-15). Place the chart deflection (inner red scale) over the weapon deflection index.
- Determine, from the plotting board, the position lateral correction. This correction is the number of meters, left or right, that it takes to move a platoon center from its location on the clear plastic disk to the vertical red line. Enter this value (to the nearest 5 meters) on DA Form 4757, column *a*.

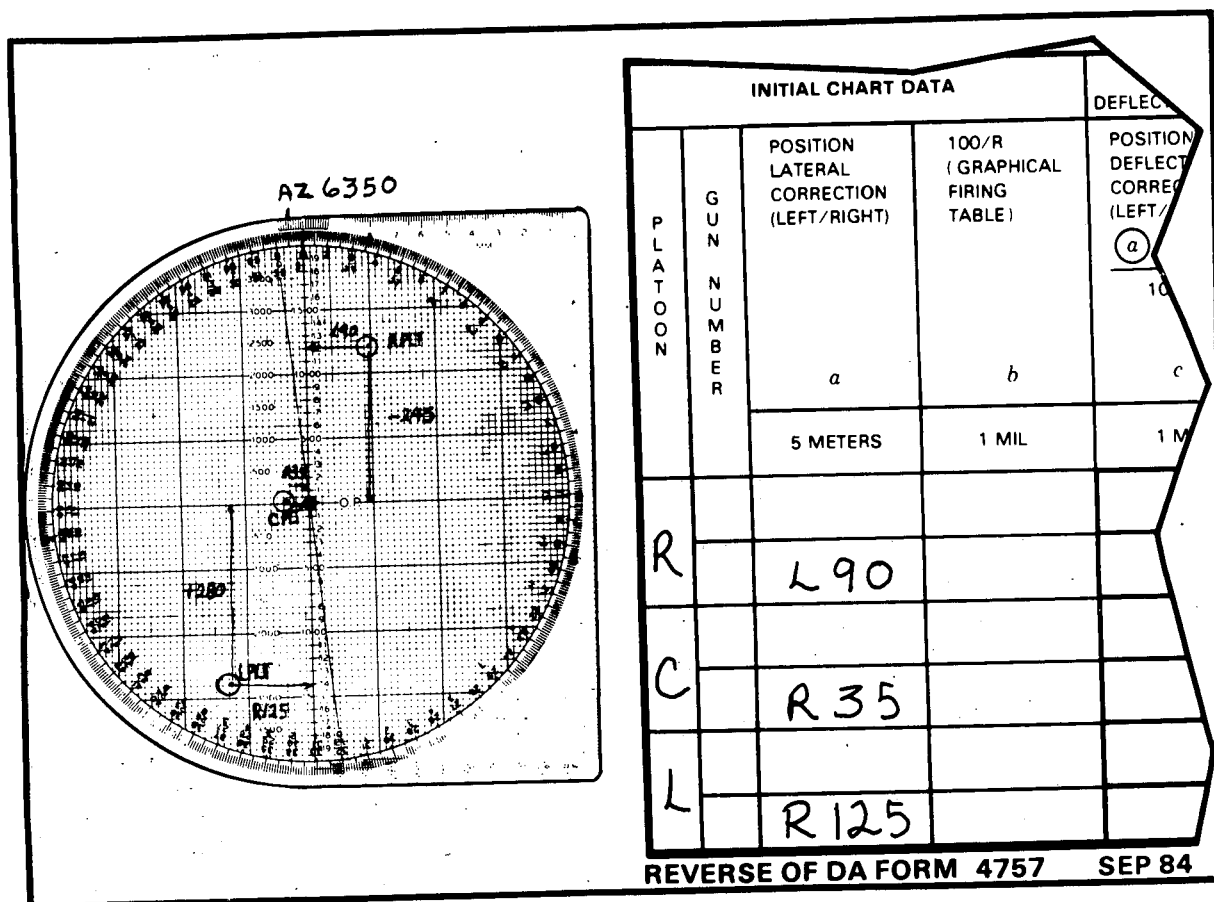


Figure 13-15. Determining position lateral corrections and recording the data.

- Determine the deflection correction. From the graphical firing table, determine the 100/R value from the MHL at the chart range. Enter this value on DA Form 4757, column *b*. On the form, in column *c*, determine the position deflection correction (fig 13-16). Determine this value by multiplying the position lateral correction by the 100/R value and dividing the product by 100. Apply the position deflection correction to the initial firing deflection.

INITIAL CHART DATA				DEFLECTION	
PLATOON	GUN NUMBER	POSITION LATERAL CORRECTION (LEFT/RIGHT)	100/R (GRAPHICAL FIRING TABLE)	POSITION DEFLECTION CORRECTION (LEFT/RIGHT)	
		a	b	$\frac{a \times b}{100}$	c
		5 METERS	1 MIL	1 MIL	
R		L90	24	L22	
C		R35	24	L8	
L		R125	24	R30	

Recorder _____
 Grid: _____
 Color: Dtr _____ Dis _____
 Zulu _____: Dtr _____
 FIRE ORDER _____
 INITIAL FIRE COMMANDS _____
 Sp Instr _____
 CTO _____

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SUBSEQUENT FIRE COMMANDS																
Dir, MF S, Fz	Dev	Qd	HOD Corr	MF, Sh, Cdg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Qd	HOD Corr	Si ()	El	OE	Exp	Typo
RPLT							3094	L22	271		271					
C PLT							3094	R8	2006		271					
L PLT							3094	R30	2006		271					

Figure 13-16. Determining deflection correction and correcting the initial deflection.

(b) *Quadrant corrections.* Determine quadrant corrections as follows:

- Determine the muzzle velocity range correction by extracting the platoon comparative VE from the FDC muzzle velocity logbook. Enter that value as an increase (I) or a decrease (D) to the nearest 0.1 meter per second on DA Form 4757, column *d*. Extract the MV unit correction factor from table F, columns 10 and 11, of the appropriate TFT, and enter it on DA Form 4757, column *e*. Determine the range correction due to platoon MV by multiplying the platoon comparative VE by the MV unit correction factor, and express the value to the nearest meter (fig 13-17).
- Determine the position range correction. This correction is the number of meters, forward or back, that it takes to move a platoon center from its location on the clear plastic disk to the horizontal red line. Enter this value (to the nearest 5 meters) on DA Form 4757, column *g* (fig 13-18).

PLATOON COMPARATIVE VELOCITY ERROR (INCREASE/ DECREASE)	MUZZLE VELOCITY UNIT CORRECTION FACTOR (TABLE F, APPROPRIATE FT) DECREASE +20.9 INCREASE -16.4	MUZZLE VELOCITY RANGE CORRECTION $(d) \times (e)$
<i>d</i>	<i>e</i>	<i>f</i>
0.1 METER PER SECOND	0.1 METER	1 METER
I 1.0	-16.4	-16
0	0	0
D 0.8	+20.9	+17

Figure 13-17. Determining range correction due to muzzle velocity.

P L A T O O N	G U N N U M B E R	POSITION LATERAL CORRECTION (LEFT/RIGHT)	POSITION DEFLECTION CORRECTION (LEFT/RIGHT) $(a) \times (b)$ 100	PLATOON COMPARATIVE VELOCITY ERROR (INCREASE/ DECREASE)	MUZZLE VELOCITY UNIT CORRECTION FACTOR (TABLE F, APPROPRIATE FT) DECREASE + INCREASE -	MUZZLE VELOCITY RANGE CORRECTION $(d) \times (e) =$	POSITIO N RANGE CORREC (FORWAR (BACK +)
		<i>a</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>f</i>	<i>g</i>
		5 METERS	1 MIL	0.1 METER PER SECOND	0.1 METER	1 METER	5 METERS
R				I 1.0	-16.4	-16.0	-245
C				0	0	0	0
L				D 0.8	+20.9	+17	+280

Figure 13-18. Recording the position range correction.

(c) *Time to fire.* Determine time to fire as follows:

- Add the total range correction (to the nearest 10 meters) on DA Form 4757, column *h*, to the initial chart range.

- Place the MHL over the corrected range and read time from the appropriate gage line (fig 13-20).

b. Adjust Fire Missions.

- (1) Determine adjusted data to the target (fig 13-21).

TOTAL RANGE CORRECTION (1) (2)	POSITION QUADRANT ELEVATION CORRECTION (3) - COLUMN 5 TABLE APPROPRIATE 11	CORRECTED RANGE (4) $\approx$ 10 METERS INITIAL RANGE 4230	TIME TO FIRE FUZE SETTING (5)
<i>h</i>	<i>i</i>		<i>k</i>
1 METER	1 MIL	10 METERS	0.1
-261	-19	3970	14.0
0	0	4230	15.0
+297	+21	4630	17.0

SUBSEQUENT FIRE COMMANDS																
Tgt	Location	Priority	Firing Unit	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si ()	EI	QE	Exp	Type
				R PLT		14.0	3074	122	3116		271		-19	252		
				C PLT		15.0	3094	R8	3086		271		0	271		
				L PLT		17.0	3094	R30	3064		271		+21	292		

Figure 13-20. Determining time to fire.

FIRE ORDER #4 (12) FZ T1 1/2										Df Corr	Si			
INITIAL FIRE COMMANDS				MF	BTRY ADJ #4				Rg	3720	Chf Df	3211	EI	224
Sp Instr				Sh	Lot		Chg	4	Fz	Ti	Df	3211	QE	226
MTO				G	(12) AC 7835		4 T 600		PER	TF	(12) FZ T1 in Eff		Ammo Exp (1)	

SUBSEQUENT FIRE COMMANDS																
Tgt	Location	Priority	Firing Unit	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si (+2)	EI	QE	Exp	Type
OS20	L100	-50	FFE				3234	0	3234	3780		+2	228	230	(2)	
			BTRY (12)				3226	0	(3226)	3820	+5	+7	231	(239)		
			SPEC CORR													
			FUZE TI													

Figure 13-21. Adjust fire mission.

M109A2/3 M198 155-ARR-2 M107		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R)									
		(METERS)									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200
MILS											
1000	4GB	20	40	60	80	100	120	140	160	180	200
1500	4GB	13	26	40	53	66	80	93	106	120	133
2000	4GB	10	20	30	40	50	60	70	80	90	100
2500	4GB	8	16	24	32	40	48	56	64	72	80
3000	4GB	6	13	20	26	33	40	46	53	60	66
3500	4GB	5	11	17	22	28	34	40	45	51	56
4000	5GB	5	10	15	20	25	30	35	40	45	50
4500	5GB	4	8	13	17	22	26	31	35	40	44
5000	5GB	4	8	12	16	20	24	28	32	36	40
5500	5GB	4	8	12	16	20	24	28	32	36	40

Figure 13-22. Hasty position deflection corrections table.

(2) Determine corrections to the final adjusted firing data for the platoons. Appendix A contains correction tables for each weapon system.

(a) *Deflection corrections.* Enter the hasty position deflection corrections table (fig 13-22) with initial chart range and platoon lateral displacement. Extract the correction value and apply it to the adjusted deflection as shown in figure 13-23.

(b) *Quadrant corrections.* Determine quadrant corrections as follows:

- Determine corrections for platoon comparative MV by entering the hasty muzzle velocity corrections table (fig 13-24) with the nearest listed value. Extract the quadrant correction for muzzle velocity and apply it as shown in figure 13-26.
- Determine corrections for platoon location by entering the hasty position quadrant elevation corrections table (fig 13-25) with initial chart range and platoon range displacement. Extract the quadrant correction for position and apply it as shown in figure 13-26.
- Determine the quadrant correction by adding the quadrant correction for

INITIAL CHART DATA		HASTY POSITION DEFLECTION CORRECTION	
PLATOON	POSITION LATERAL CORRECTION (LEFT/RIGHT)	DEFLECTION CORRECTION (L/R)	
	a	b	
	5 METERS	AS LISTED	
R	R120	L34	
C	L30	R8	
L	L150	R42	

Priority	Firing Unit	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si ()	El
		BTRY (12)			3226	01	3226	3820	+5	+7	231
		SPEC CORR									
		FUZE T1									
		R PLT			3226	L34	3260				
		C PLT			3226	R8	3218				
		L PLT			3226	R42	3184				

Figure 13-23. Applying hasty position deflection corrections.

M109A2/3 M198 155-AM-2 M107		HASTY MUZZLE VELOCITY CORRECTIONS (M/S)									
		-5	-1.0	-1.5	-2.0	-2.5	-3.0	-3.5	-4.0	-4.5	-5.0
		+5	+1.0	+1.5	+2.0	+2.5	+3.0	+3.5	+4.0	+4.5	+5.0
RANGE	CHG	MILS									
1000	4GB	+0	+0	+1	+1	+1	+1	+1	+2	+2	
		-0	-0	-0	-1	-1	-1	-1	-1	-2	
1500	4GB	+0	+0	+0	+1	+1	+1	+1	+2	+2	+2
		-1	-1	-1	-1	-2	-2	-2	-2	-2	-3
2000	4GB	+0	+0	+1	+1	+1	+2	+2	+3	+3	+3
		-1	-1	-1	-2	-2	-2	-2	-3	-3	-3
2500	4GB	+0	+0	+1	+1	+2	+2	+3	+3	+3	+4
3000	4GB										
3500	4GB	+0	+0	+1	+1	+1	+2	+2	+3	+3	+3
		-1	-1	-2	-2	-2	-3	-3	-4	-4	-4
5500	5GB	+0	+0	+1	+1	+2	+2	+3	+3	+3	+4
		-0	-0	-1	-1	-2	-2	-3	-3	-3	-4
6000	5GB	+0	+0	+1	+1	+2	+2	+3	+3	+4	+4
		-1	-1	-2	-2	-3	-3	-4	-4	-5	-5
6500	5GB	+0	+0	+1	+1	+2	+2	+3	+3	+4	+4
		-1	-2	-2	-2	-3	-3	-4	-4	-5	-5

Figure 13-24. Hasty muzzle velocity corrections

M109A2/3 M198 155-AM-2 M107		HASTY POSITION QUADRANT ELEVATION CORRECTIONS											
		(METERS)											
		20	40	60	80	100	120	140	160	180	200		
RANGE	CHG	MILS											
		1	2	3	4	6	7	8	9	10	12		
1000	4GB	1	2	3	4	6	7	8	9	10	12		
1500	4GB	1	2	3	4	6	7	8	9	10	12		
2000	4GB	1	2	3	4	6	7	8	9	10	12		
2500	4GB	1	2	3	4	6	7	8	9	10	12		
3000	4GB	1	2	3	4	6	7	8	9	10	12		
		1	2	3	4	6	7	8	9	10	12		
4500	5GB												
5000	5GB	1	2	3	4	6	7	8	9	10	12		
5500	5GB	1	2	3	4	6	7	8	9	10	12		
6000	5GB	1	2	3	4	6	7	8	9	10	12		
6500	5GB	1	3	4	6	8	9	11	12	14	16		

Figure 13-25. Hasty position quadrant elevation corrections table.

PLAYGROUNDS COMPARATIVE MUZZLE VELOCITY VARIATION	HASTY MUZZLE CORRECTION - (1)	POSITION RANGE CORRECTION (FORWARD BACK -)	HASTY POSITION QUADRANT ELEVATION CORRECTION	TOTAL QUADRANT ELEVATION CORRECTION (1) - (1)
0.1 METER PER SECOND	AS LISTED	5 METERS	AS LISTED	1 MIL
I 1.0	-1	-235	-14	-15
0	0	-5	0	0
D0.8	+1	+265	+15	+16

Tgt	Location	Unit	MF, Sh, Chg, Fz	FS Corr	Ti	Chart DI	DI Corr ()	DI Fired	Chart Rg	MOB Corr	Si ()	EI	QE	Exp	Type
			BTRY (2)			3226	0	(3226)	3820	+5	+7	231	(238)		
			SPEC CORR:												
			FZ T1												
			R PLT			3226	L34	3260		238	-	15	223		
			C PLT			3226	R9	3218		239		0	238		
			L PLT			3226	R42	3184		238	+16		254		

Figure 13-26. Applying hasty position quadrant elevation corrections.

DATE TIME GROUP		
TOTAL QUADRANT ELEVATION CORRECTION	CORRECTED QUADRANT ELEVATION SITE FIRED ELEVATION	TIME TO FIRE ELEVATION GAGE LINE OVER READ TIME
1 MIL	1 MIL	0.1
	216	12.3
	231	13.5
	247	14.0

SUOSEQUENT FIRE COMMANDS																
Yr	Location	Priority	Unit	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Of	Df Corr ()	Df Fired	Chart Dg	HOO Corr	Si (+7)	EI	QE	Exp	Type
		+	50	FFE	BTCY(13)											
					SPEC. CORR											
					F2 T1											
					R PLT	12.3	3226	L34	3260		238	-	15	223		
					C PLT	13.5	3226	R8	3210		238		0	238		
					L PLT	14.0	3226	R42	3184		238	+	16	254		

Figure 13-27. Determining time to fire.

position to the quadrant correction for muzzle velocity. Add the quadrant correction to the adjusted quadrant and subtract site as shown in figure 13-27.

(c) *Time to fire.* To determine time to fire for each platoon, subtract the site from the quadrant to fire (fig 13-27). Place the elevation gage line over the elevation, and read time to fire from the appropriate gage line.

13-15. SPECIAL SHEAF

a. *Plotting Grid, Attitude, and Length Targets.* Target attitude is the grid azimuth (0 to 3,200 mils) of the long axis of the target. The grid sent by the observer is the grid location of the center of the target. This grid is represented by the center rivet on the plotting board. The target must be drawn to scale on the plotting board disk (fig 13-28) and must be in correct relationship to the direction of fire (azimuth of lay 6350).

(1) Orient the disk with the attitude of the target (1400) on the outer black scale opposite the azimuth index.

(2) Using the same scale as the one on which the pieces are plotted, draw the target to scale on the clear plastic disk. Over the vertical center line, draw a line starting one

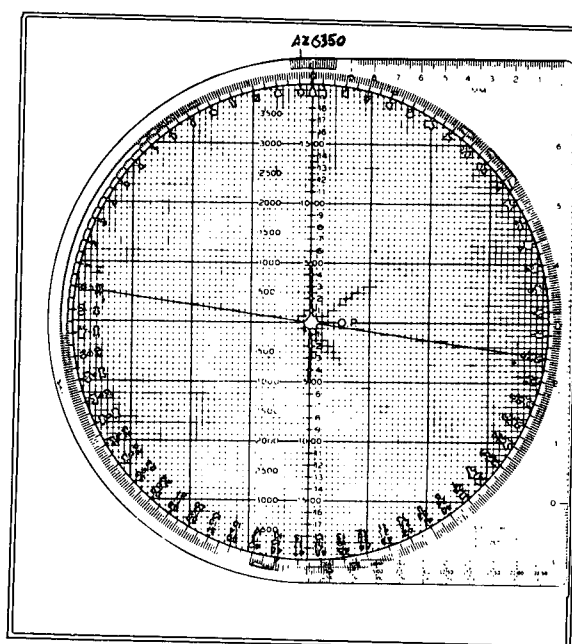


Figure 13-28. Drawing a grid, attitude, and length target.

half the target length above the center rivet and extend the line to one half the target length below the center rivet.

(3) To place individual platoon aiming points on a linear target, divide the length of the target by the number of firing units (platoons) minus one unit (fig 13-29).

(4) Set off the chart deflection to the target (inner red scale) over the red index arrow. The target is now graphically portrayed with respect to the line of fire.

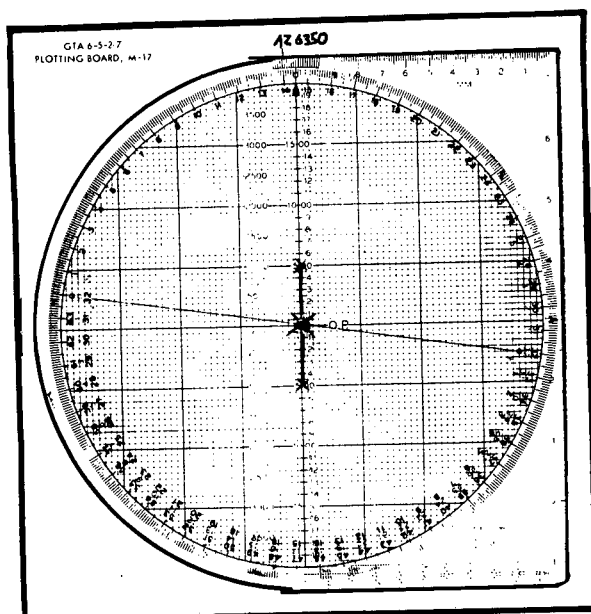


Figure 13-29. Placing individual aiming points.

EXAMPLE:

The following call for fire is received:

RECORD OF FIRE				PS	
Observer B6 H23	CALL FOR FIRE	Tgt			100/R
Grid: 6093 3897	AF (FF) IS/ S				/R
Polar: Dir	Dis	U/D	VA		20/R
Shift	Dir	U/R	+/-	U/D	HOB Corr
CONVOY ON ROAD LENGTH 200M ALTITUDE 1400				Si ÷ 10	10m Si
FIRE ORDER				Df Corr	Si
INITIAL FIRE COMMANDS				Chf Df	El
FM MF				Rg	

Draw the target on the M17 plotting board as described in paragraphs (1), (2), and (3) above. The battery has three platoons ($3 - 1 = 2$). A 200-meter-long target divided by 2 equals 100 meters. Plot the first burst point at one end of the target, and then move toward the other end in 100-meter increments. The last burst point should plot at the other end of the target. When the initial azimuth of lay is 6,350 mils and the initial chart deflection is 3,207 mils, the plotting board should look like that shown in figure 13-30.

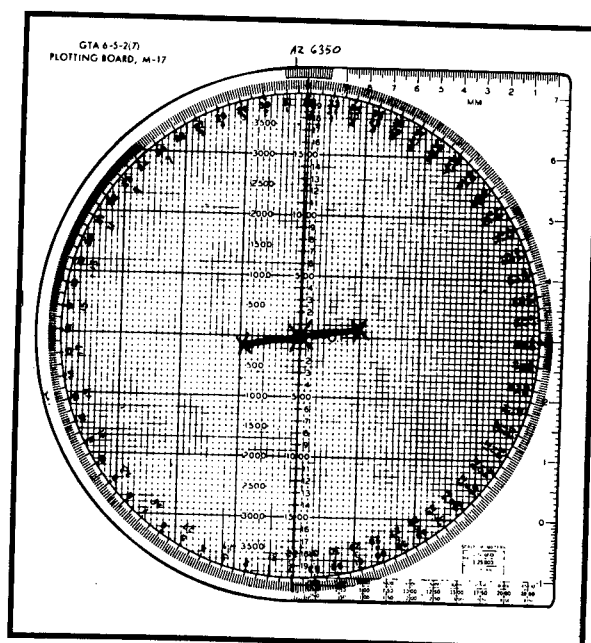


Figure 13-30. Target in relation to the azimuth of fire.

(5) Now compute the special corrections as follows:

(a) Determine chart data (GBC to target center) to the target.

(b) Determine initial firing data (deflection and quadrant) on the basis of the chart data (fig 13-31).

(c) Use DA Form 4757 to determine corrections to the initial deflection and quadrant and to determine the time to fire. Use the following procedures for each platoon or gun:

RECORD OF FIRE									
CALL FOR FIRE					TGT ALT 400 DFT L11		△ FS		
Observer _____ AF/FFE/IS/S _____ Tgt _____					BTRY 355 GFT RS		100/R 15		
Grid: _____					V1 +45		/R		
Polar: Dir _____ Dis _____ U/D _____ VA _____							20/R		
Shift _____: Dir _____ L/R _____ +/- _____ U/D _____							MOB Corr		
					Si ÷ 10		10m Si		
FIRE ORDER HAST CORR FZ TI ② AMC					Df Corr L6		Si +9		
INITIAL FIRE COMMANDS ☒ JM ☒ MF BTRY ②					Rg 6520		Chf Df 3207		EI 472
Sp Instr AMC SPEC CORR					Sh HE	Lot XY	Chg 4	Fz T1	Ti —
MTO					T		Df 3213		QE 481
					PER	TF	in Eff		Ammo Exp
Tgt	Location	Priority	Firing	SUBSEQUENT FIRE COMMANDS					

Figure 13-31. Initial firing data.

INITIAL CHART DATA		DEFLECTION		RANGE	
PLATOON	GUN NUMBER	POSITION LATERAL CORRECTION (LEFT RIGHT)	100 R GRAPHICAL FIRING TABLE	POSITION DEFLECTION CORRECTION (LEFT RIGHT)	PLATOON COMPARATIVE VELOCITY ERROR (INCREASE DECREASE)
		a	b	c	d
		5 METERS	1 MIL	1 MIL	0.1 METER PER SECOND
R	1				
	2	L 20			
C	3				
	4	R 35			
L	5				
	6	R 65			

Figure 13-32. Determining position lateral corrections and recording the data.

- Determine deflection corrections as follows:

Orient the M10/M17 plotting board. Place chart deflection (inner red scale) over the red index arrow.

Determine the position lateral correction from the platoon center to the red vertical line that passes through the platoon aiming point. Enter this value (to the nearest 5 meters) on DA Form 4757, section III, column *a* (fig 13-32).

Determine the deflection correction. From the graphical firing table, determine the 100/R value from the MHL at the chart range. Enter this value on DA Form 4757, column *b*.

On DA Form 4757, column *c*, determine the position deflection correction by multiplying the position lateral correction by the 100/R value and dividing the product by 100. Apply the position deflection correction to the initial firing deflection (fig 13-33).

INITIAL CHART DATA		DEFLECTION	
PLATOON	GUN NUMBER	POSITION LATERAL CORRECTION (LEFT RIGHT)	100 R GRAPHICAL FIRING TABLE
		a	b
		5 METERS	1 MIL
R	1		
	2	L 20	15
C	3		
	4	R 35	15
L	5		
	6	R 55	15

Chg	4	Fz	T	Ti	Df	(3213)	QE	(481)
PER		TF			in Eff		Ammo Exp	

Tgt	Location	Priority	Firing Unit	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si ()	EI	QE	Exp	Type
				R PLT			3213	L 3	3216							
				C PLT			3213	R 5	3208							
				L PLT			3213	R 8	3205							

Figure 13-33. Determining the deflection correction and applying it to the initial deflection.

- Determine quadrant corrections as follows:

Determine the muzzle velocity range correction by extracting the platoon comparative VE from the FDC muzzle velocity logbook. Enter the value as an increase (I) or a decrease (D) to the nearest 0.1 meter per second on DA Form 4757, column *d*. Extract the MV unit correction factor from table F, columns 10 and 11, of the appropriate TFT, and enter the value on DA Form 4757, column *e*. Determine the range correction due to platoon comparative muzzle velocity by multiplying the platoon comparative VE by the MV unit correction factor. Express the MV range correction to the nearest meter (fig 13-34).

DEFLECTION		RANGE		TARGET
POSITION DEFLECTION CORRECTION (LEFT - RIGHT)	PLATOON COMPARATIVE VELOCITY ERROR (INCREASE - DECREASE)	MUZZLE VELOCITY UNIT CORRECTION FACTOR (TABLE F, APPROPRIATE FT.) DECREASE - INCREASE	MUZZLE VELOCITY RANGE CORRECTION (I - D)	POSITION RANGE CORRECTION (FORWARD - BACK -)
(a) - (b)			(d) - (e)	
100				
	<i>d</i>	<i>e</i>	<i>f</i>	<i>h</i>
1 MIL	0.1 METER PER SECOND	0.1 METER	1 METER	5 METERS
	I 1.0	-24.4	-24	
	0	-	0	
	00.8	+31.3	+25	

Figure 13-34. Determining the muzzle velocity range correction.

Determine the position range correction. This correction is the number of meters (forward or back) that it takes to move a platoon center from its location on the clear plastic disk to the horizontal red line that passes through the platoon aiming point. Enter the value (to the nearest 5 meters) on DA Form 4757, section III, column *g*.

Determine the total range correction by adding the MV range correction to the position range correction (fig 13-35).

Determine the correction to quadrant by converting the total range correction to a position quadrant elevation correction (fig 13-36). Enter table F, column 5, and extract the change in range for a 1-mil change in elevation. Divide the total range correction by the value from table F, column 5. The quotient is the position quadrant correction. Apply that value to the initial firing quadrant.

RANGE		TARGET		
PLATOON COMPARATIVE VELOCITY ERROR (INCREASE DECREASE)	MUZZLE VELOCITY UNIT CORRECTION FACTOR (TABLE F APPROPRIATE FT.) DECREASE - INCREASE	MUZZLE VELOCITY RANGE CORRECTION (d - e)	POSITION RANGE CORRECTION (FORWARD - BACK -)	TOTAL RANGE CORRECTION (f - h)
d	e	f	g	h
0.1 METER PER SECOND	0.1 METER	1 METER	5 METERS	1 MET
I 1.0	-24.4	-244	-230	-25
0	-	0	0	0
00.8	+31.2	+25	+265	+290

EDITION OF OCTOBER 1978 IS OBSOLETE

Figure 13-35. Determining the position range correction.

- Determine time to fire as follows:

Determine the corrected range by adding the total range correction (to the nearest 10 meters) on DA Form 4757, column *h*, to the initial chart range.

Determine the time to fire by placing the MHL over the corrected range and reading time from the appropriate gage line (fig 13-37).

PLATOON COMPARATIVE VELOCITY ERROR (INCREASE DECREASE)	MUZZLE VELOCITY UNIT CORRECTION FACTOR (TABLE F APPROPRIATE FT.) DECREASE - INCREASE +	MUZZLE VELOCITY RANGE CORRECTION (d) - (e)	POSITION RANGE CORRECTION (FORWARD - BACK +)	TOTAL RANGE CORRECTION (f) - (g)	POSITION QUADRANT ELEVATION CORRECTION (h) - COLUMN 5 TABLE F APPROPRIATE FT.
d	e	f	g	h	i
0.1 METER PER SECOND	0.1 METER	1 METER	5 METERS	1 METER	1 MIL
I 1.0	-24.4	-24	-230	-254	-28
0	-	0	0	0	0
D 0.8	+31.3	+25	+265	+290	+32

Chart Df		EI
Fz	Ti	Df (3213)
in Eff		Ammo Exp
4		481

Dir, MF Sh, Fz	Dev	Rg	NOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	NOB Corr	Si ()	EI	QE	Exp	Type
				R PLT			3213	L3	3216				481	-28	453	
				C PLT			3213	R5	3208				481	0	481	
				L PLT			3213	R8	3205				481	+32	513	

Figure 13-36. Determining and applying the correction to quadrant.

TARGET			DATE TIME GROUP		
MUZZLE VELOCITY RANGE CORRECTION (d) - (e)	POSITION RANGE CORRECTION (FORWARD - BACK +)	TOTAL RANGE CORRECTION (f) - (g)	POSITION QUADRANT ELEVATION CORRECTION (h) - COLUMN 5 TABLE F APPROPRIATE FT.	CORRECTED RANGE (i) - (j) 10 METERS INITIAL RANGE	TIME (k) FIRE FUZE SETTING (l)
f	g	h	i	j	k
1 METER	5 METERS	1 METER	1 MIL	10 METERS	0.1
		-254	-28	6270	24.4
		0	0	6520	25.8
		+290	+32		27.5

Dir, MF Sh, Fz	Dev	Rg	NOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	NOB Corr	Si ()	EI	QE	Exp	Type
				R PLT			3213	L3	3216				481	-28	453	
				C PLT			3213	R5	3208				481	0	481	
				L PLT			3213	R8	3205				481	+32	513	

Figure 13-37. Determining time to fire.

b. Plotting Two-Grid Targets.

(1) When a target is described by two grids by the observer, the location of the center grid of the target must be computed to allow determination of chart range and chart deflection to only one point. This computation also allows the center of the target to be represented by the center rivet. Using grids 168198 and 171196, determine the center grid. The center grid can be determined very rapidly by inspection by use of the following procedures:

(a) Determine the difference in eastings announced by the observer.

$$\begin{array}{r} 17100 \\ -16800 \\ \hline 300 \text{ meters} \end{array}$$

$$\begin{array}{r} 16800 \text{ numerically smaller easting} \\ +150 \\ \hline 16950 \text{ easting to center of target} \end{array}$$

(d) Perform steps (a) and (b) above for northing.

$$\begin{array}{r} 19800 \\ -19600 \\ \hline 200 \text{ meters} \end{array}$$

$$200 \div 2 = 100 \text{ meters}$$

(e) Add 100 meters to the numerically smaller northing. The resulting value is the northing to the center of the target.

$$\begin{array}{r} 19600 \text{ numerically smaller northing} \\ +100 \\ \hline 19700 \text{ northing to center of target} \end{array}$$

(f) The center grid to the target is 16950 19700.

(2) Determine the difference in easting and northing from the target center to the grids sent by the observer.

(b) Divide the 300 meters by 2.

$$300 \div 2 = 150 \text{ meters}$$

(c) Add 150 meters to the numerically smaller easting. The resulting value is the easting to the center of the target.

	EASTING	NORTHING
Target center	16950	19700
Target grid	<u>16800</u>	<u>19800</u>
Difference	150	100

(3) Visualize the attitude the two requested grids would form on a map (fig 13-38).

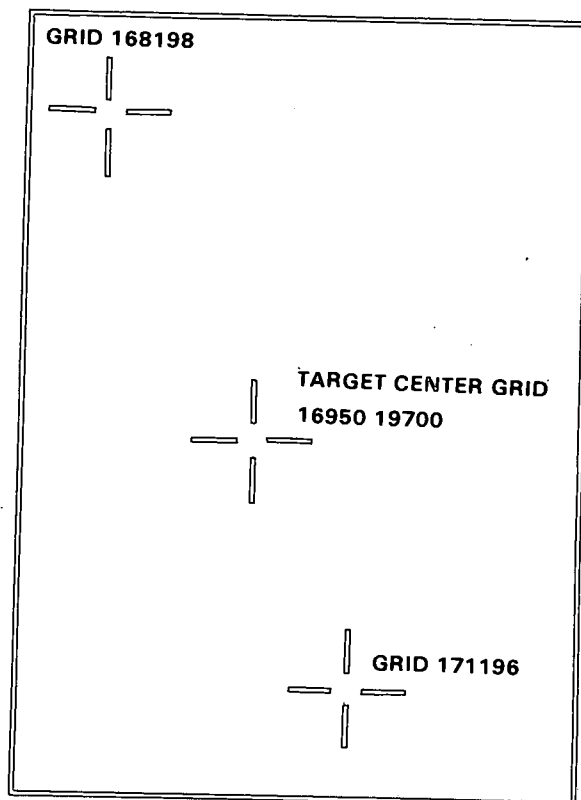


Figure 13-38. Visualizing the attitude of the target.

(4) Orient the disk with the 0 (outer black scale) opposite the azimuth index. This orients the clear disk north. The center of the plotting board represents target center grid; for example, 1695 1970.

(5) On the plotting board, measure the differences in easting from the center rivet along the center horizontal line.

(6) On the basis of visualization of the target attitude, measure the differences in northing along a line parallel to the center vertical line. Make marks on the clear plastic disk at those points. The target grids sent by the observer are now portrayed on the plotting board.

(7) Connect the two plotted points by drawing a straight line through the center of the plotting board. The target has now been described on the clear plastic disk (fig 13-39).

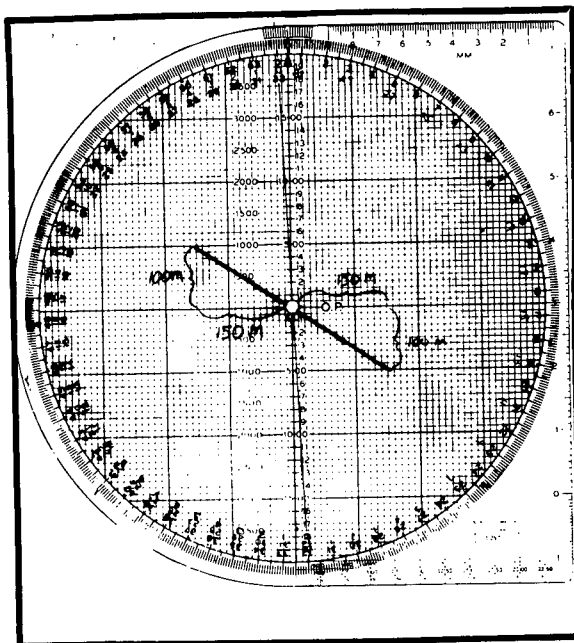


Figure 13-39. Plotting a two-grid target.

(8) Rotate the disk until the target described on the disk is over the center horizontal or vertical line on the base. This provides a scale to mark off the distance between bursts along the target. For placing bursts on a linear target, see paragraph 13-15a(3).

(9) Now compute special corrections as described in paragraph 13-12.

c. Plotting Three-Grid Targets. When the observer describes a target with three grids (the middle grid represented by the center rivet on the plotting board), use the following procedures:

(1) Orient the disk to grid north (fig 13-40). Place the 0 (outer black scale) opposite the azimuth index.

(2) Determine the differences in easting and northing of the middle grid and the target end point grids. For example, use grids 168197, 169198, and 170197.

(3) Plot the differences in easting and northing for each leg of the target from the middle grid on the plotting board. Plot easting parallel to the center horizontal line and northing parallel to the center vertical line.

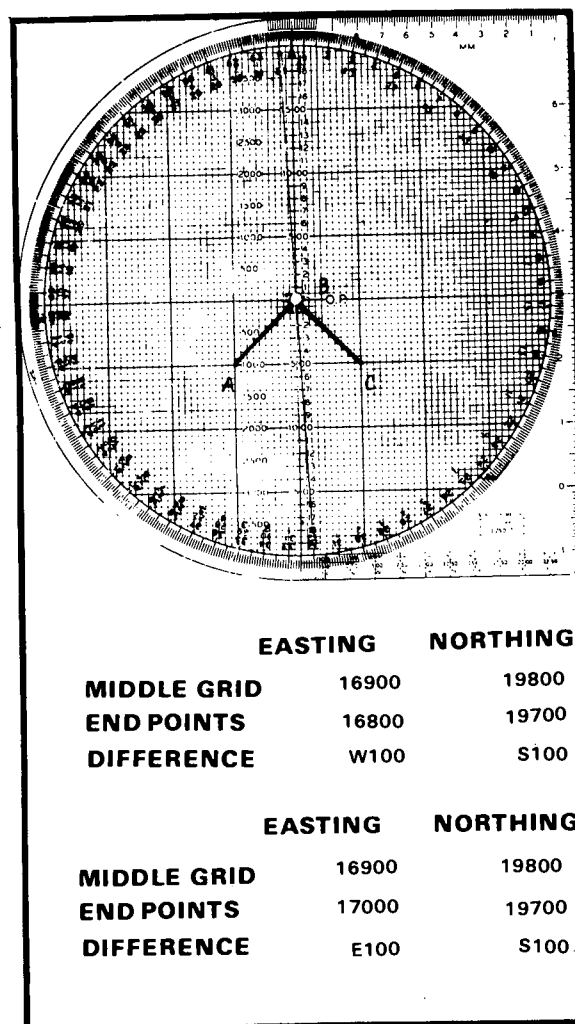


Figure 13-40. Plotting a three-grid target.

(4) Connect each plotted point to the center of the plotting board with a straight line.

(5) Determine the total target length by rotating the disk until one of the constructed lines of the target on the disk is over the center vertical or horizontal line on the base. This provides a scale to measure the length of that target leg. Measure the other target leg in the same manner to determine the total length of the target.

(6) Use the total target length to place platoon aiming points. Determine and mark the distance between the aiming points. For placing bursts on a linear target, see paragraph 13-15a(3).

(7) Orient the plotting board by setting off the chart deflection to the middle grid (inner red scale) over the deflection index to graphically portray the target in relation to the line of fire. When using a chart deflection of 3,600 mils over the deflection index, the target should look like the one shown in figure 13-41.

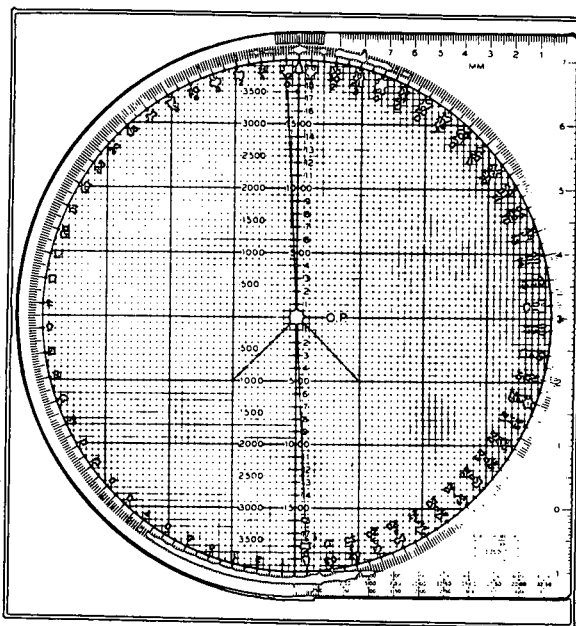


Figure 13-41. Target in relation to the azimuth of fire.

(8) Now compute special corrections as described in paragraph 13-12.

d. Plotting Circular Targets With a Radius Greater Than 100 Meters. When the observer describes a circular target that has a radius greater than 100 meters, use the following procedures:

Note. The grid identified in the call for fire is represented by the center rivet.

(1) Draw the target on the clear plastic disk by measuring, from the center rivet, the radius of the target along the center vertical line. Holding your pencil at that point, spin the clear plastic disk 6,400 mils, describing the target on the plastic disk.

(2) Identify the platoon aiming points. Orient azimuth 0 (outer black scale) over the

red index arrow. Measure up from the center rivet one half the target radius, and place a dot at that point. Perform the same procedure at azimuths 2130 and 4260. This procedure gives the circle three platoon aiming points (fig 13-42).

(3) Now compute special corrections as described in paragraph 13-12.

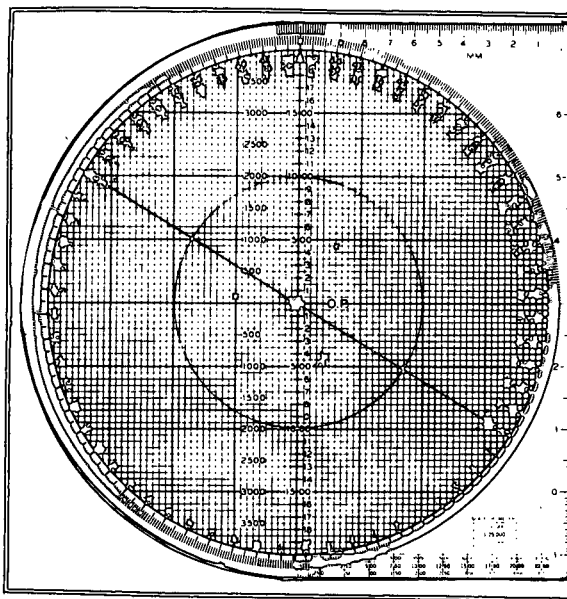


Figure 13-42. Circular target with a radius greater than 100 meters.

13-16. FADAC

Position correction procedures with FADAC are in the FADAC job aids.

13-17. BATTERY COMPUTER SYSTEM

The battery computer system determines trajectories for each firing piece to individual piece aiming points.

13-18. HAND-HELD CALCULATOR

The hand-held calculator can be used to expedite the mathematics required in the registration/special correction work sheet.

Section III ATTACK OF LARGE TARGETS

13-19. METHODS OF ATTACK

In a FADAC/manual FDC or an FDC equipped with the BCS operating autonomously, the FDO decides how to attack a target. He should use the graphical munitions effectiveness table (GMET) and the joint munitions effectiveness manual (JMEM) as guides when determining the volume of fire to place on a target. Many calls for fire may have targets larger than can be considered by use of the GMET. The largest target radius considered by use of the GMET is 250 meters. Large or irregularly shaped targets require special fire distribution techniques to ensure proper coverage with the most effective use of the ammunition available. This section describes various successful methods of attacking large targets. It does not include *all* possible methods. The FDO and S3 should use the technique that best accomplishes the mission.

13-20. TARGET DIVISION METHOD

a. Targets that exceed the firing capability of one battery should be sent to battalion FDC for additional fires. However, there are times when the battery is forced to fire on such targets. When this occurs, the battery FDO may divide the target into subtargets to distribute the fires effectively.

(1) A call for fire from an observer is received by the battery FDC.

**T2A16, THIS IS B6H23,
FIRE FOR EFFECT, OVER.
GRID 614376, OVER.
WHEELED VEHICLE CONVOY ON
ROAD,
LENGTH 600, ATTITUDE 1600,
OVER.**

(2) The battery FDO requests additional fires from battalion, but the other batteries are engaged.

(3) The FDO can divide the target into three 200-meter lengths (fig 13-43). The FDO must compare the target attitude with the direction of fire to determine how best to divide the target. In this case, the battery first fires on one third of the target and then fires on the other two thirds.

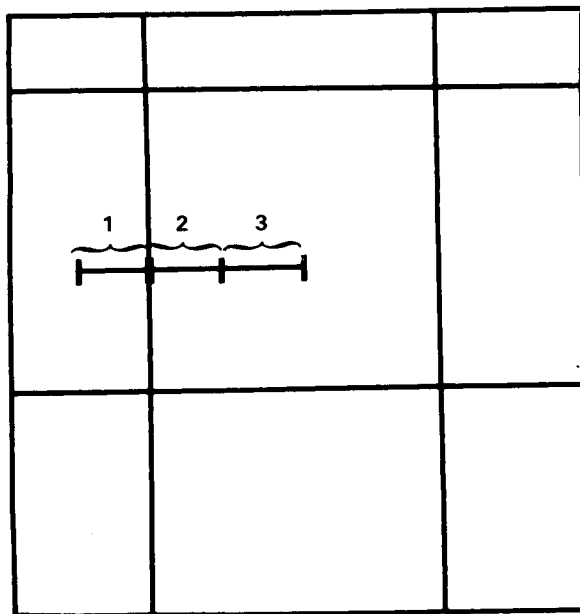


Figure 13-43. Target division.

b. The battalion FDO normally divides large or irregularly shaped targets into subtargets for each battery. In the battalion fire order, the appropriate subtargets are announced for each battery. The subtargets announced to each battery may require further division. The battalion FDO should issue guidance in his fire order on how to subdivide the subtarget. For example, a target is submitted to the battalion FDC by division artillery.

**GRID 630363, 600 by 100,
ATTITUDE 650.**

(1) A map inspection indicates that the center battery can fire grid 630363, the leftmost battery can fire grid 632366, and the rightmost battery can fire grid 629361.

(2) If the subtargets described above had required further subdivision (for example, sweep and zone), the battalion FDO could have designated how the batteries were to attack the target.

FIRE FOR EFFECT, BATTALION,
ALPHA GRID 632366,
BRAVO GRID 630363,
CHARLIE GRID 629361,
ATTITUDE 365, DPICM 4 ROUNDS,
SWEEP AND ZONE, TIME ON
TARGET.

(3) As an alternate method, the FDO could have said:

FIRE FOR EFFECT, BATTALION,
ALFA GRID 632366,
BRAVO GRID 630363,
CHARLIE GRID 629361,
ALTITUDE 650, ATTITUDE 365,
PLACE BURSTS 65 METERS APART,
DPICM, 4 ROUNDS, TIME ON
TARGET.

This indicates to each battery not only the center grid but also the type of sheaf (indicated by a width of 65 meters between piece aiming points) they are to fire.

c. The linear target table may be used to divide linear targets into battery or two-gun platoon subtargets. Table 13-1 is used for the

155-mm howitzer, but a table may be constructed for any caliber or configuration. The first column lists the target length. The second column lists the number of meters each battery must add or drop along the long axis of the target to determine the end-point grid for its subtarget. The third column lists the interval between platoon targets.

EXAMPLE:

The battalion FDC receives the following call for fire:

D26 THIS IS D12,
FIRE FOR EFFECT, OVER.
GRID 938182, OVER.
INFANTRY IN TREE LINE,
LENGTH 800, ATTITUDE 1900,
OVER.

(1) The chart operator plots the target and orients the target grid along the attitude of the target.

(2) All computers ensure that each battery has monitored the call for fire, or they pass the call for fire to the battery.

(3) Each battery chart operator also plots the target and orients the target grid.

(4) The battalion FDO examines the plot and, on the basis of the attitude of the

Table 13-1. Linear target table—155-mm howitzer.

TARGET LENGTH (METERS)	NUMBER OF METERS +/-	PLATOON INTERVAL
1,500	700	165
1,400	650	150
1,300	600	140
1,200	550	130
1,100	500	120
1,000	450	110
950	425	100
900	400	100
850	375	90
800	350	85
750	325	80
700	300	75
650	275	70
600	250	65
550	225	55
500	200	50

target with reference to the position of the firing batteries, determines that Battery C will attack the left portion of the target, Battery B will attack the center of the target, and Battery A will attack the right portion of the target. Using the linear target table, the FDO determines the number of meters a battery will add or drop and the platoon aiming point interval. He then issues the fire order.

**FIRE FOR EFFECT, BATTALION,
ALFA, LEFT PLATOON, DROP 350,
INTERVAL ADD 85;
BRAVO, CENTER PLATOON,
INTERVAL 85;
CHARLIE, RIGHT PLATOON, ADD
350, INTERVAL DROP 85;
ALTITUDE 370,
3 ROUNDS, TIME ON TARGET.**

(5) The Battery C chart operator drops 350 meters along the attitude and announces the chart data for the left platoon. He adds 85 meters and announces the data for the center platoon. He then adds another 85 meters and announces the data for the right platoon.

(6) The Battery B chart operator announces the chart data to the announced grid for the center platoon, adds 85 meters, and announces the data for the right platoon. He drops 85 meters from the center of the target and announces the data for the left platoon.

(7) The Battery A chart operator adds 350 meters along the attitude and announces the chart data for the right platoon. He then drops 85 meters and announces the data from the center platoon and drops another 85 meters and announces the left platoon.

13-21. MASSED FIRE DISTRIBUTION TEMPLATE METHOD

Large or irregularly shaped targets are plotted on the firing chart by the massed fire distribution template method. A locally constructed massed fire distribution template drawn to scale for the firing chart is placed

over the plotted target to allow the user to determine the optimum aiming points for the required number of firing elements to mass fires.

a. Constructing the Template. Overlay paper is the best material for constructing the template. Each tick mark placed on the template represents an aiming point for a firing element (fig 13-44). A separate template is required for each caliber, munition type, and size of firing element (one gun, platoon, or battery). The distance between tick marks is based on the radius of effects of the particular weapon system and munitions to be fired. Refer to FM 101-60-17 (C) and the appropriate JMEM. Each tick mark represents the center mass of rounds fired by a firing element (weapon, platoon, or battery).

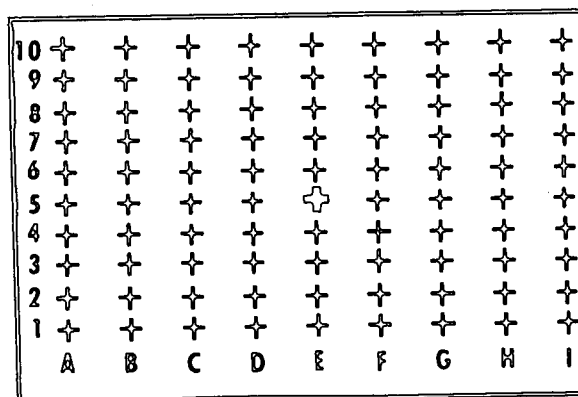


Figure 13-44. Example of a high-explosive distribution template.

b. Using the Template. Place the center tick mark (E-5 in fig 13-44) over the center of the target or the nearest grid intersection. Orient the template north-south or east-west. Then determine the points within the target area to attack.

13-22. SWEEP AND ZONE FIRES

In rare instances a battery (or a 3x8 platoon) may fire alone on a large target on which sweep and/or zone fires are required. Surprise is lost as multiple volleys are fired. The fire unit may also be in greater danger of

being located by enemy target acquisition devices. When firing sweep or zone fires, each platoon will first be assigned an aiming point by use of special sheaf techniques. Then manual computations can be done to determine the number of additional sets of firing data for the sweep or zone fires. Sweep or zone techniques cannot be controlled effectively for units occupying large areas unless the special sheaf technique is applied before sweep or zone instructions are assigned. These techniques parallel the BCS procedures for computing sweep and zone fires.

a. Sweep Fire. When the target is wide enough (in relation to the direction of fire), sweep fires may be used. In sweep fire, the weapons fire constant quadrant elevations with several different deflections (fig 13-45).

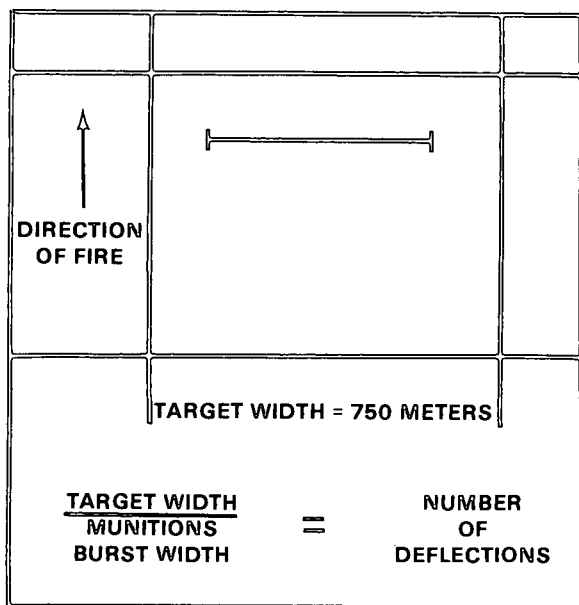


Figure 13-45. Example of sweep fire for a three-platoon battery.

Note. The above table is based on unclassified data from FM 6-141-1.

(1) Determine the total number of deflections to be fired. Divide the width of the target by the munitions effective burst width. Express the value to the next higher whole number. This value is also the number of rounds to fire.

Table 13-2. Munitions effective burst widths.

CALIBER	MUNITION TYPE	EFFECTIVE BURST WIDTH (METERS)
105 mm	HE	30
	ICM	35
155 mm	HE	50
	APICM	60
	DPICM	50
203 mm	HE	80
	APICM	70
	DPICM	80

(2) Determine the sweep (in mils). Divide the effective burst width by the range to the target (in thousands).

$\frac{\text{Munitions effective burst width}}{\text{Range to target (in thousands)}} = \text{sweep (in mils)}$

EXAMPLE:

An M109A3 battery is occupying a very large position. The FDC receives an urgent call for fire on a target 750 meters wide and 250 meters deep along the direction of fire. No other fire units are available to mass. The FDC decides to attack the target with platoon special sheaf and sweep fires by use of HE rounds.

Given:

Range to the center of the target 5,000 meters

Deflection to the center of the target 3,218 mils

The FDC assigns platoon aiming points along the target center line, perpendicular to the line of fire. The FDC determines the number of deflections to be fired.

$\frac{\text{Target width}}{\text{Munitions effective burst width}} = \frac{750}{50} = 15 \text{ deflections}$

The FDC determines the sweep (in mils).

$\frac{\text{Effective burst width}}{\text{Range to target (in thousands)}} = \frac{50}{5} = 10 \text{ mils}$

(3) Fire commands for sweep fire are as follows:

**BATTERY (so many) ROUNDS,
SWEEP (so many) MILS,
(so many) DEFLECTIONS, CHARGE
(so and so)**

Deflection and quadrant are also announced for each platoon. The weapons fire the deflection and quadrant announced in the fire command first. The remaining data are fired according to the order stated in unit SOP.

b. Zone Fire. When the target is deep enough in relation to the direction of fire, zone fires may be used to attack the target. In zone fire, the weapons fire constant deflections with several different elevations (fig 13-46).

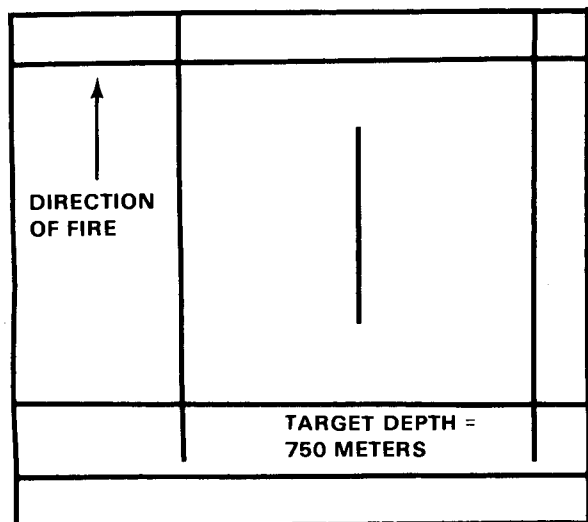


Figure 13-46. Example of zone fire for a three-platoon battery.

(1) Use special sheaf techniques to assign aiming points on a line perpendicular to the direction of fire from the center of the fire unit to the center of the target.

(2) Determine the total number of QEs to be fired. Divide the depth of the target by the munitions effective burst width. Express the value to the next higher whole number.

$$\frac{\text{Target depth}}{\text{Munitions effective burst width}} = \text{total QEs to fire}$$

(3) Determine the mil change for zone fire.

(a) Add the value of the munitions effective burst width to the range to the target center.

(b) Determine the QE for the range determined in (a) above.

(c) Determine the QE for the range to the target center.

(d) Subtract the QE for the center range of the target from the QE determined in paragraph (b) above. The results are the zone mil change.

(4) Announce zone fire in the fire commands as follows:

**BATTERY (so many) ROUNDS,
ZONE (so many) MILS,
(so many) QUADRANTS,
CHARGE (so and so), DEFLECTION
(so and so), QUADRANT ELEVATION
(so and so)**

Deflection is announced for each platoon. The weapons fire the deflection and QE announced in the fire command first. The remaining data are fired according to the order given in unit SOP.

EXAMPLE:

An M109A3 battery is occupying a very large position. The FDC receives an urgent call for fire on a target that is 750 meters deep and 250 meters wide along the direction of fire. No other fire support means are available. The FDO decides to attack the target with platoon special sheaf and zone fires by use of HE rounds. Charge 4GB is being fired, and a current GFT setting is in effect.

Given: Range to the center of the target is 5,000 meters and site is $\times 4$ mils. The FDC assigns platoon aiming points along the target center line. The FDC determines the number of quadrants to be fired.

Target depth

Munitions effective burst width

$$= \frac{750}{50} = 15 \text{ quadrants}$$

Munitions effective burst width

The FDC determines the mil change for zone fire.

Munitions effective burst width	50 meters
Range to target	+ 5,000 meters
	<u>5,050 meters</u>

QE corresponding to range 5,050 meters

e1	328
si	+ 4
<u>QE</u>	<u>332</u>

QE corresponding to range 5,000 meters

e1	323
si	+ 4
<u>QE</u>	<u>327</u>

Difference in QEs

332
<u>-327</u>
5 mils

Therefore each weapon will fire QE 327 and seven QEs over and seven QEs short of QE 327 in 5-mil increments.

Quadrant elevation:

362 357 352 347 342 337 332 **327** 322 317 312 307 302 297 292

c. Combination Sweep and Zone Fires. When very wide and very deep targets are to be attacked by one fire unit, a combination of sweep and zone fires can be used.

Section IV FINAL PROTECTIVE FIRE

13-23. DESCRIPTION

A final protective fire is an immediately available, prearranged barrier of fire designed to protect friendly troops and installations by impeding enemy movements across defensive lines or areas. The normal use of FPF is to establish prearranged close-in defense. This defense includes other artillery fires, minefields, obstacles, final protective machine gun lines, small arms fire, and mortar final protective fire. Each battery

can be assigned one FPF and normally is laid on the FPF data when not firing other missions. The FPF may be fired on a prearranged signal or fired on call from the supported unit. An FPF may be repeated on call as often as necessary. When time, ammunition, and the tactical situation permit, the data for the FPF may be verified or corrected by the firing of check rounds. A battery FPF may be fired either individually or in coordination with the FPF of other batteries.

a. Width (or Length) of the Final Protective Fire. The width (or length) of the FPF that can be covered by a single battery without shifting its fire should not exceed six effective burst widths of the type ammunition to be fired. When necessary, the artillery commander and the commander of the supported unit may agree to increase the width of the final protective fire. However, increasing the width of the FPF will decrease the effectiveness of fire.

b. Preparation and Update of Data. The actual grid location and attitude of the FPF are reported by the FIST. Since the FPF usually is located within a very short distance of positions occupied by friendly troops, precise computational procedures must be used, and all available corrections must be applied. Special corrections in the form of calibration corrections and position corrections, obtained by use of the M17 plotting board, are determined and applied as individual piece corrections. It is critical that FPF data be constantly updated with changes in met, propellant temperature, and projectile and propellant lots. The FPF data must also be updated when survey is updated or when more current registration data become available for the ammunition, charge, and angle of fire to be used in the final protective fires.

c. Ballistic Computers. Ballistic computers are also used for computation of final protective fire data. See the appropriate job aids for a more detailed discussion.

13-24. MANUAL COMPUTATION OF DATA WITH THE GFT OR TFT

a. Observer-Adjusted Final Protective Fire. In an observer-adjusted FPF, the observer adjusts the center weapon in the battery onto the center point of the FPF line. The adjusted data are used as the initial firing data to apply special corrections as described in section II. Each individual piece should be adjusted if time and the tactical situation permit.

b. Final Protective Fire Not Adjusted. When the situation does not permit the adjustment of the center weapon onto the center point of the FPF line, the FDC computes special corrections for each weapon to an aiming point on the FPF line as described in section II.

Section V OBSERVERS

13-25. AIR OBSERVER CONSIDERATIONS

Air observers (AO) often encounter three problems that require special assistance from the fire direction center.

a. The AO seldom has a fixed direction to the target. Normally, he is flying up and down, in and around the target area. Therefore, FDC personnel must be prepared for unusual and changing observer directions or spotting lines. Every adjustment will probably have a different observer direction.

b. The AO may lose his perception of distances while in the air. He may request ranging rounds (two rounds impacting 400 meters apart) as an aid to visualizing distances in the target area. The observer and the FDC personnel must realize that ranging rounds fired along the gun-target line may disclose to the enemy the firing unit's general location.

c. The AO must minimize the time he is exposed to enemy detection. In forward areas, the pilot must fly close to the earth and behind cover as much as possible. The AO

and his pilot therefore require from the FDC very accurate time of flight, shot, and splash so that the pilot can unmask the aircraft 2 to 3 seconds before the round impacts.

13-26. OBSERVER DIRECTIONS/SPOTTING LINES

a. Grid Coordinates and Gun-Target Line. If the AO knows the location of the firing unit in relation to the target, he may choose to adjust along the gun-target line. When he announces **DIRECTION, GUN-TARGET LINE** or implies GT line by his omission of a direction, the chart operator plots the target and centers the target grid along the arm of the RDP over the target. This sets up the GT line on the chart.

b. Shift From a Known Point Along the Gun-Target Line. The AO may designate **DIRECTION, GUN-TARGET LINE** for a shift from a known point. In this instance, the chart operator plots the known point, centers the target grid, and orients it for the gun-target line. The chart operator plots the AO's shift and determines chart data. He then rotates the target grid around the new pinhole so that the arrow is parallel to the gun-target line (the arm of the RDP).

c. Cardinal Direction. The AO may choose to adjust along a cardinal direction (one of the eight principal points of the compass) (fig 13-47). The RPV will always

use grid north to adjust rounds. When the AO announces a cardinal direction, the chart operator converts the direction into mils and orients the target grid to that direction. Direction southwest (SW) is converted to direction 4,000 mils by the fire direction center. The AO may also shift from a known point by use of a cardinal direction.

d. Helicopter Instrument Readings for Direction. When the AO's aircraft is changing locations and popping up and down and in and around the target area, he may use the aircraft instrument readings for his observer direction. Since this direction is expressed in degrees, FDC personnel must convert the reading to mils by use of the following relationship:

Direction in degrees $\times 17.8$ = direction in mils

Direction: 250°

$250^\circ \times 17.8$ mils = direction 4,450 mils

Note. In preparation for AO missions, the chart operator should mark a target grid in degrees or prepare a conversion chart for quick conversion from degrees to mils.

e. Spotting Line. The AO may adjust along lines formed by natural or man-made terrain features such as roads, railroads, canals, or ridge lines. Prior to flight, if possible, the AO selects the line, determines the direction, and notifies the fire direction center. While in flight, he may select a line that is readily identifiable and convenient. The AO may describe the feature in detail and have FDC personnel determine the direction from a map by use of a protractor. The chart operator orients the target grid on that direction.

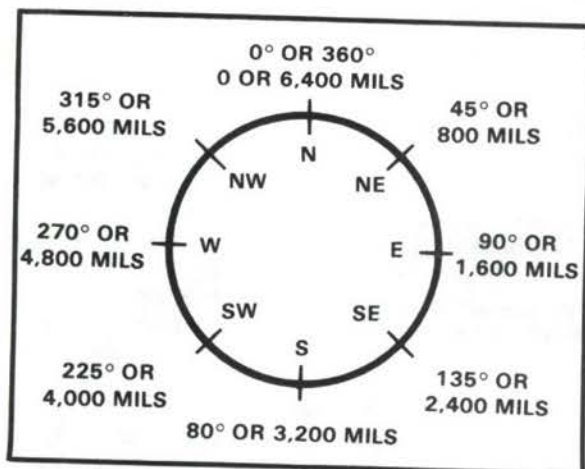


Figure 13-47. Cardinal direction.

13-27. RANGING ROUNDS

In his call for fire, the AO may announce **REQUEST RANGING ROUNDS**. This indicates that he desires to see a volley of two rounds that impact 400 meters apart at relatively the same time. Ranging rounds are fired only as a last resort. They are fired along the gun-target line (fig 13-48). The chart operator determines initial chart data, and

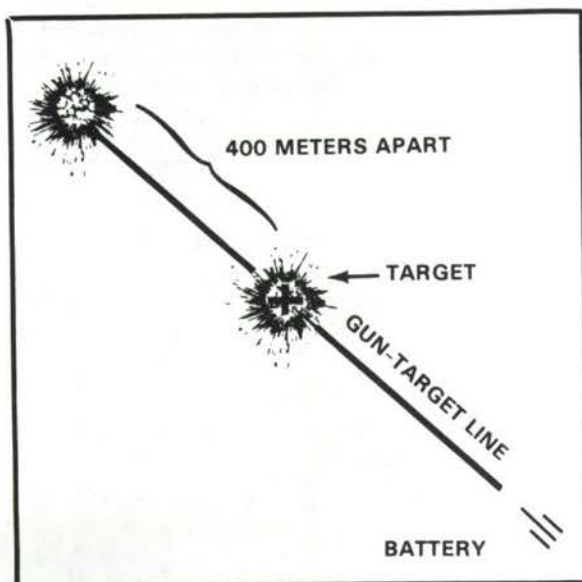


Figure 13-48. Ranging rounds.

the computer determines initial firing data for the adjusting piece. The computer then adds 400 meters to the announced chart range. Using the new range and the initial chart deflection, the computer determines firing data for the second piece to fire in the volley (usually, the other piece in the center platoon). The ranging rounds are fired simultaneously by firing **AT MY COMMAND**. When the AO observes the impact of the rounds and determines the corrections necessary to hit the target, he

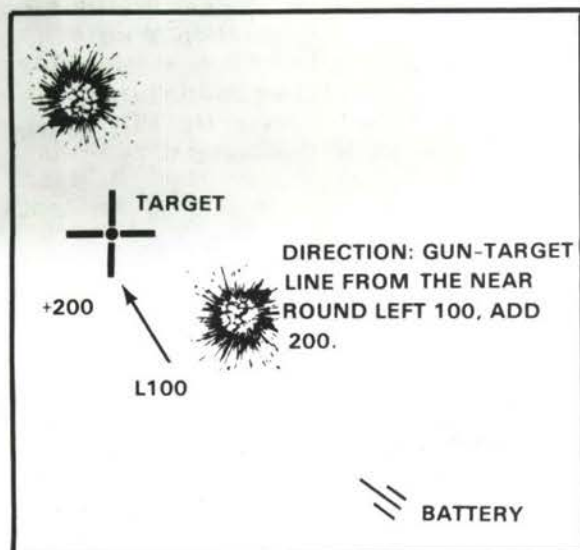


Figure 13-49. Adjusting from a ranging round.

may base his corrections on whichever round landed closest to the target. He must specify to the FDC from which round he is adjusting, and the chart operator plots the shift accordingly (fig 13-49).

13-28. TIME OF FLIGHT/ SHOT/SPLASH

In the message to observer, the FDC must specify the time of flight. On all volleys, the FDC must promptly announce **SHOT** and **SPLASH**. The FDC should be watchful for changes in the time of flight as the mission progresses.

13-29. COMPUTER PROCEDURES

Direction in degrees must be converted to mils. When firing ranging rounds, the FADAC procedures parallel those for illumination range spread. If the GT line override is left enabled, the FADAC will compute and use a new GT line for each subsequent correction. Normally, the first GT line computed (with the initial round) should be used throughout the mission. See the appropriate job aids for a discussion.

13-30. UNTRAINED OBSERVERS

Calls for fire from untrained personnel acting as ground observers require close attention and initiative from FDC personnel. The FDC personnel must be prepared to assist the untrained observer in his call for fire and adjustment of artillery.

a. The FDC personnel must take the initiative if the observer is hesitant or confused in his request for fire support. They must ask leading questions such as the following:

- (1) Where is the target?

- (a) What are the grid coordinates of the target?

(b) Where is the target in relation to a readily identifiable natural or man-made feature?

(c) What is your location? How far is the target from your location and in what direction?

(2) Is the target personnel, vehicles, armored, or wheeled?

(a) What is the size of the enemy force?

(b) What are they doing at present?

(c) If they are moving, which way are they headed? How fast are they moving?

(3) How close is the target to you? If they are within 600 meters or closer to other friendly troops, the observer must "creep" the rounds to the target.

(4) What is your direction to the target?

(a) What is the azimuth in degrees or mils?

(b) What is the cardinal direction (N, NE, E, SE, S, SW, W, NW)?

(c) Is the direction along a natural or man-made feature?

(5) What effect on the target do you need?

(a) Is the target shooting at you?

(b) Is it necessary to obscure the target's vision?

(c) Do we need to neutralize the target or destroy it?

b. Explain to the observer what artillery fire he is getting.

(1) You will see one round that will look like a cloud of dust. You will get more rounds when you move the burst within 50 meters or so of the target.

(2) The round is now on the way and will impact in 10 seconds.

c. Help the observer make corrections. The FDC personnel must help the observer move the rounds to the target and must be prepared for unusual shifts or combinations of shifts. To obtain corrections, they should ask leading questions such as the following:

(1) Where did the round(s) land in relation to the target?

(a) Did it land left or right? How much?

(b) Did it land over or short? How much? (Ask for dimensions in meters or in the number of football-field lengths.)

(2) Did the round land closer to the target than the previous round?

Note. The FDO should consider employing shell WP to mark the center of sector.

d. Use sound judgment. The FDC personnel must decide whether or not to require the observer to authenticate his mission. They must be on the watch for possible observer misorientation. Also, FDC personnel must help the observer determine when a satisfactory effect on the target has been achieved. In all cases, the FDC must take the initiative in these situations.

Section VI ZONE-TO-ZONE TRANSFORMATION

13-31. DESCRIPTION

a. Zone-to-zone transformation is the method used to change coordinates and/or azimuths of one zone to coordinates and/or azimuths of the adjacent zone.

b. In the universal transverse mercator (UTM) grid system, there are several areas

around the world in which artillery units may have to fire across UTM zone junctions. When this occurs, it is necessary to transform the grid coordinates of points and grid azimuths of lines of one zone to those of the adjacent zone.

c. Figure 13-50 shows two adjacent UTM zones—14 and 15. The coordinates for (P)

in the 14th zone are 800370. If (P) were to be expressed in the terms of zone 15, its coordinates would be much different. The same situation exists in terms of direction from point (X) to trig marker (T). In zone 14, it is obviously different from what it would be in zone 15.

d. Zone-to-zone transformation can be accomplished by the following three means:

- (1) Cutting and joining two grid sheets.
- (2) Using the graphic method.
- (3) Using the computation method.

e. Maps printed by the Army map service show the differences between UTM grid zones. Maps that cover an area within 25 miles of a UTM zone junction are printed with two sets of grid line numbers around the border—one set for each zone. One set is printed in black; the other set is printed in blue and corresponds to the adjoining grid zone. Marginal information on the maps also indicates the color that applies to each zone.

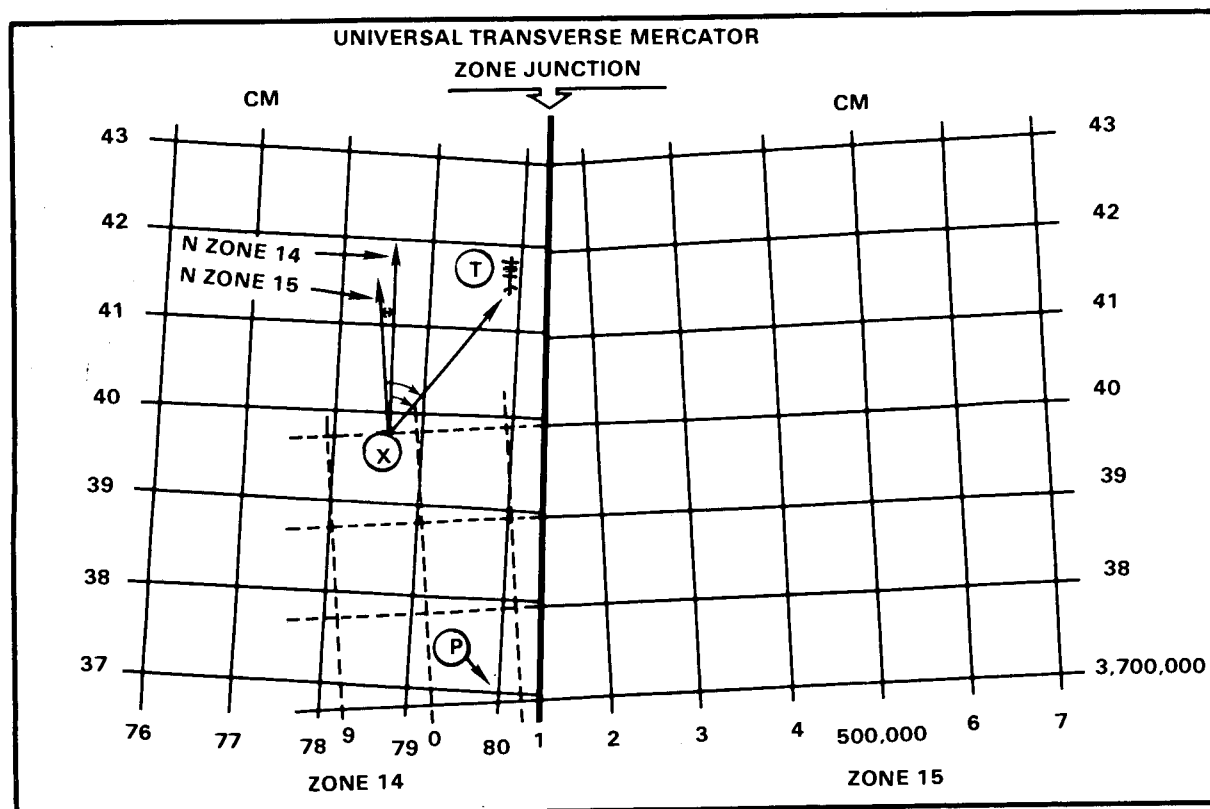


Figure 13-50. Adjacent universal transverse mercator zones.

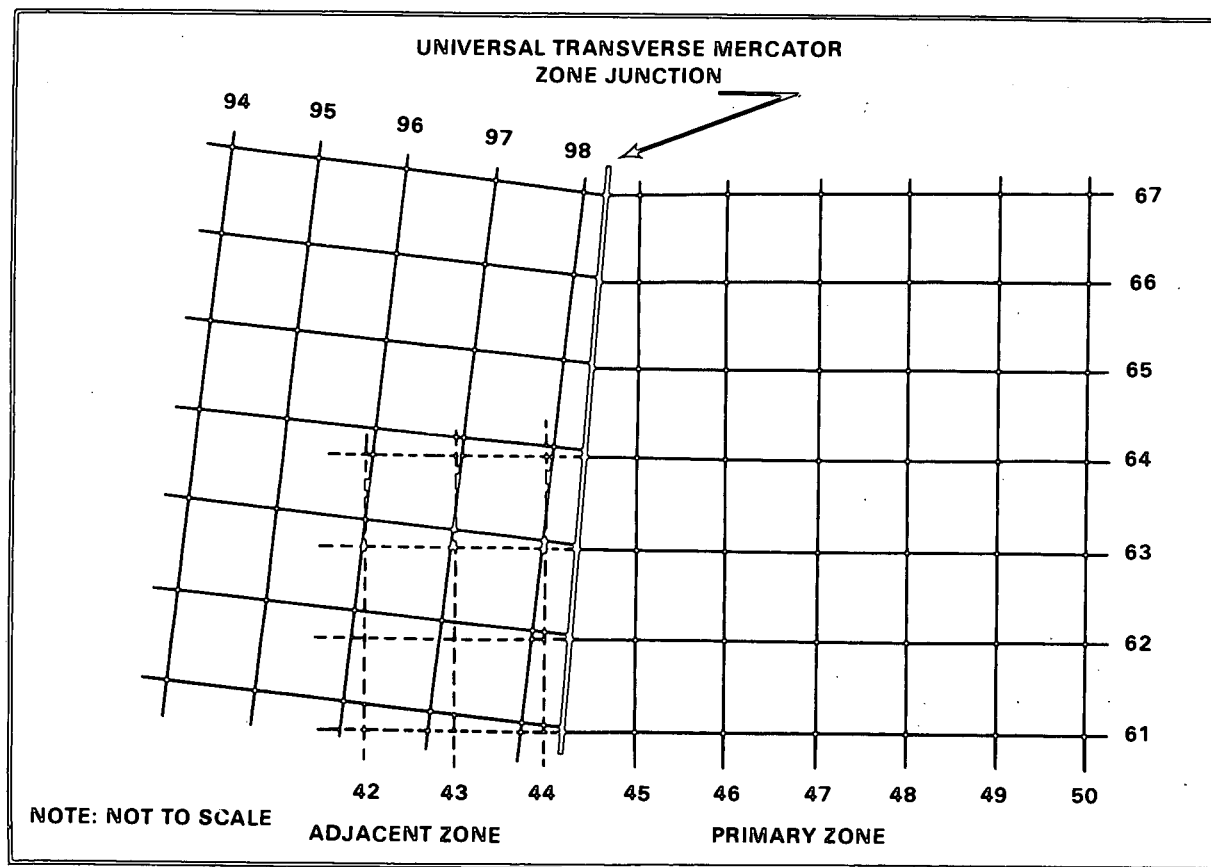


Figure 13-51. Joining two grid sheets.

13-32. CUTTING AND JOINING TWO GRID SHEETS

The fastest and simplest method of zone-to-zone transformation is cutting and joining two grid sheets. Two grid sheets are prepared and joined to form a large chart (a constructed grid sheet) from which chart data across the zone junction can be determined automatically (fig 13-51).

a. Preparation of Grid Sheets. The chart operator prepares a piece of chart paper (a grid sheet) for each grid zone involved. Using a plotting scale and a sharp pencil, the chart operator reproduces on the grid sheets the exact orientation of the zone junction longitudinal and latitudinal lines as they appear on the map(s) of the area of overlap. The edges that are to be joined should be marked with a fine line on the basis of

accurate measurements taken from the map(s). Care should be taken in cutting and taping so that when the sheets are put together to form one large chart, measurements from this large chart can be made accurately.

b. Use of the Constructed Grid Sheet. When firing data are determined from a constructed grid sheet, no transformation or computations are necessary. The coordinates are measured and plotted from the grid lines for the respective area. The observer's azimuth is used as announced, and the target grid is emplaced by using grid north of the observer's zone.

13-33. GRAPHIC METHOD

a. Designation of the Primary Zone. Either of the UTM zones may be

designated as the primary zone. Designation of the primary zone is based on the tactical situation, unit SOP, the directives of the commander, or the anticipated location of future operations.

b. Preparation of the Map.

(1) After the primary zone has been designated, the map of each zone should be prepared for transformation. If two maps are used, they are lined up along the common UTM zone junction longitudinal line.

(2) The FDO and a chart operator, using the arm of the RDP or a long straightedge, trace the grid lines of the primary zone into the secondary zone on the map.

(3) The east-west grid lines of the primary zone are extended by use of the tick marks around the border and are numbered with the appropriate values. The north-south grid lines are constructed similarly. The superimposed grid lines should be drawn with a colored pen to facilitate the rapid transformation of data and to reduce the possibility of errors.

c. Determination of Chart Data.

(1) Number the firing chart with the number designations of the grid lines of the primary zone.

(2) When the call for fire is received and the observer's target location lies in the adjacent zone, plot the target location on the map by using the normal grid lines of the adjacent zone.

(3) Using the superimposed grid lines of the primary zone, determine a new set of coordinates for the target. Plot the new coordinates on the firing chart, and determine chart data by use of standard fire direction procedures.

(4) For adjust fire missions, the next step is to convert the observer direction in the secondary zone to the corrected direction in the primary zone. In this case, the observer has not done this previously using his own map.

(5) Compute the correction factor applied to the observer's direction by use of table 14 of the current Army Ephemeris (fig 13-52).

N	C	DIFF IN C	DIFF IN N	F
0	0.0	.842	★	★
100 000	0.842	.842	0.18	15.24
200 000	1.684	.841	0.26	7.62
300 000	2.525	.842	0.31	5.08
400 000	3.367	.841	0.36	3.81
500 000	4.208	.841	0.40	3.05
600 000	5.049	.841	0.44	2.54
700 000	5.890	.840	0.48	2.18
800 000	6.730	.840	0.51	1.91
900 000	7.570	.840	0.54	1.70
1 000 000	8.410	.840	0.57	1.51
1 100 000	9.250	.840	0.60	1.31
1 200 000	10.090	.840	0.63	1.11
1 300 000	10.930	.840	0.66	0.91
1 400 000	11.770	.840	0.69	0.71
1 500 000	12.610	.840	0.72	0.51
1 600 000	13.450	.840	0.75	0.31
1 700 000	14.290	.840	0.78	0.11
1 800 000	15.130	.840	0.81	0.00
1 900 000	15.970	.840	0.84	0.00
2 000 000	16.810	.840	0.87	0.00
2 100 000	17.650	.840	0.90	0.00
2 200 000	18.490	.840	0.93	0.00
2 300 000	19.330	.840	0.96	0.00
2 400 000	20.170	.840	0.99	0.00
2 500 000	21.010	.840	1.02	0.00
2 600 000	21.850	.840	1.05	0.00
2 700 000	22.690	.840	1.08	0.00
2 800 000	23.530	.840	1.11	0.00
2 900 000	24.370	.840	1.14	0.00
3 000 000	25.210	.840	1.17	0.00
3 100 000	26.050	.840	1.20	0.00
3 200 000	26.890	.840	1.23	0.00
3 300 000	27.730	.840	1.26	0.00
3 400 000	28.570	.840	1.29	0.00
3 500 000	29.410	.840	1.32	0.00
3 600 000	30.250	.840	1.35	0.00
3 700 000	31.090	.840	1.38	0.00
3 800 000	31.930	.840	1.41	0.00
3 900 000	32.770	.840	1.44	0.00
4 000 000	33.610	.840	1.47	0.00
4 100 000	34.450	.840	1.50	0.00
4 200 000	35.290	.840	1.53	0.00
4 300 000	36.130	.840	1.56	0.00
4 400 000	36.970	.840	1.59	0.00
4 500 000	37.810	.840	1.62	0.00
4 600 000	38.650	.840	1.65	0.00
4 700 000	39.490	.840	1.68	0.00
4 800 000	40.330	.840	1.71	0.00
4 900 000	41.170	.840	1.74	0.00
5 000 000	42.010	.840	1.77	0.00
5 100 000	42.850	.840	1.80	0.00
5 200 000	43.690	.840	1.83	0.00
5 300 000	44.530	.840	1.86	0.00
5 400 000	45.370	.840	1.89	0.00
5 500 000	46.210	.840	1.92	0.00
5 600 000	47.050	.840	1.95	0.00
5 700 000	47.890	.840	1.98	0.00
5 800 000	48.730	.840	2.01	0.00
5 900 000	49.570	.840	2.04	0.00
6 000 000	50.410	.840	2.07	0.00
6 100 000	51.250	.840	2.10	0.00
6 200 000	52.090	.840	2.13	0.00
6 300 000	52.930	.840	2.16	0.00
6 400 000	53.770	.840	2.19	0.00
6 500 000	54.610	.840	2.22	0.00
6 600 000	55.450	.840	2.25	0.00
6 700 000	56.290	.840	2.28	0.00
6 800 000	57.130	.840	2.31	0.00
6 900 000	57.970	.840	2.34	0.00
7 000 000	58.810	.840	2.37	0.00
7 100 000	59.650	.840	2.40	0.00
7 200 000	60.490	.840	2.43	0.00
7 300 000	61.330	.840	2.46	0.00
7 400 000	62.170	.840	2.49	0.00
7 500 000	63.010	.840	2.52	0.00
7 600 000	63.850	.840	2.55	0.00
7 700 000	64.690	.840	2.58	0.00
7 800 000	65.530	.840	2.61	0.00
7 900 000	66.370	.840	2.64	0.00
8 000 000	67.210	.840	2.67	0.00
8 100 000	68.050	.840	2.70	0.00
8 200 000	68.890	.840	2.73	0.00
8 300 000	69.730	.840	2.76	0.00
8 400 000	70.570	.840	2.79	0.00
8 500 000	71.410	.840	2.82	0.00
8 600 000	72.250	.840	2.85	0.00
8 700 000	73.090	.840	2.88	0.00
8 800 000	73.930	.840	2.91	0.00
8 900 000	74.770	.840	2.94	0.00
9 000 000	75.610	.840	2.97	0.00
9 100 000	76.450	.840	3.00	0.00
9 200 000	77.290	.840	3.03	0.00
9 300 000	78.130	.840	3.06	0.00
9 400 000	78.970	.840	3.09	0.00
9 500 000	79.810	.840	3.12	0.00
9 600 000	80.650	.840	3.15	0.00
9 700 000	81.490	.840	3.18	0.00
9 800 000	82.330	.840	3.21	0.00
9 900 000	83.170	.840	3.24	0.00
10 000 000	84.010	.840	3.27	0.00
10 100 000	84.850	.840	3.30	0.00
10 200 000	85.690	.840	3.33	0.00
10 300 000	86.530	.840	3.36	0.00
10 400 000	87.370	.840	3.39	0.00
10 500 000	88.210	.840	3.42	0.00
10 600 000	89.050	.840	3.45	0.00
10 700 000	89.890	.840	3.48	0.00
10 800 000	90.730	.840	3.51	0.00
10 900 000	91.570	.840	3.54	0.00
11 000 000	92.410	.840	3.57	0.00
11 100 000	93.250	.840	3.60	0.00
11 200 000	94.090	.840	3.63	0.00
11 300 000	94.930	.840	3.66	0.00
11 400 000	95.770	.840	3.69	0.00
11 500 000	96.610	.840	3.72	0.00
11 600 000	97.450	.840	3.75	0.00
11 700 000	98.290	.840	3.78	0.00
11 800 000	99.130	.840	3.81	0.00
11 900 000	99.970	.840	3.84	0.00
12 000 000	100.810	.840	3.87	0.00
12 100 000	101.650	.840	3.90	0.00
12 200 000	102.490	.840	3.93	0.00
12 300 000	103.330	.840	3.96	0.00
12 400 000	104.170	.840	3.99	0.00
12 500 000	105.010	.840	4.02	0.00
12 600 000	105.850	.840	4.05	0.00
12 700 000	106.690	.840	4.08	0.00
12 800 000	107.530	.840	4.11	0.00
12 900 000	108.370	.840	4.14	0.00
13 000 000	109.210	.840	4.17	0.00
13 100 000	110.050	.840	4.20	0.00
13 200 000	110.890	.840	4.23	0.00
13 300 000	111.730	.840	4.26	0.00
13 400 000	112.570	.840	4.29	0.00
13 500 000	113.410	.840	4.32	0.00
13 600 000	114.250	.840	4.35	0.00
13 700 000	115.090	.840	4.38	0.00
13 800 000	115.930	.840	4.41	0.00
13 900 000	116.770	.840	4.44	0.00
14 000 000	117.610	.840	4.47	0.00
14 100 000	118.450	.840	4.50	0.00
14 200 000	119.290	.840	4.53	0.00
14 300 000	120.130	.840	4.56	0.00
14 400 000	120.970	.840	4.59	0.00
14 500 000	121.810	.840	4.62	0.00
14 600 000	122.650	.840	4.65	0.00
14 700 000	123.490	.840	4.68	0.00
14 800 000	124.330	.840	4.71	0.00
14 900 000	125.170	.840	4.74	0.00
15 000 000	126.010	.840	4.77	0.00
15 100 000	126.850	.840	4.80	0.00
15 200 000	127.690	.840	4.83	0.00
15 300 000	128.530	.840	4.86	0.00
15 400 000	129.370	.840	4.89	0.00
15 500 000	130.210	.840	4.92	0.00
15 600 000	131.050	.840	4.95	0.00
15 700 000	131.890	.840	4.98	0.00
15 800 000	132.730	.840	5.01	0.00
15 900 000	133.570	.840	5.04	0.00
16 000 000	134.410	.840	5.07	0.00
16 100 000	135.250	.840	5.10	0.00
16 200 000	136.090	.840	5.13	0.00
16 300 000	136.930	.840	5.16	0.00
16 400 000	137.770	.840	5.19	0.00
16 500 000	138.610	.840	5.22	0.00
16 600 000	139.450	.840	5.25	0.00
16 700 000	140.290	.840	5.28	0.00
16 800 000	141.130	.840	5.31	0.00
16 900 000	141.970	.840	5.34	0.00
17 000 000	142.810	.840	5.37	0.00
17 100 000	143.650	.840	5.40	0.00
17 200 000	144.490	.840	5.43	0.00
17 300 000	145.330	.840	5.46	0.00
17 400 000	146.170	.840	5.49	0.00
17 500 000	147.010	.840	5.52	0.00
17 600 000	147.850	.840	5.55	0.00
17 700 000	148.690	.840	5.58	0.00
17 800 000	149.530	.840	5.61	0.00
17 900 000	150.370	.840	5.64	0.00
18 000 000	151.210	.840	5.67	0.00
18 100 000	152.050	.840	5.70	0.00
18 200 000	152.890	.840	5.73	0.00
18 300 000	153.730	.840	5.76	0.00
18 400 000	154.570	.840	5.79	0.00
18 500 000	155.410	.840	5.82	0.00
18 600 000	156.250	.840	5.85	0.00
18 700 000	157.090	.840	5.88	0.00
18 800 000	157.930	.840	5.91	0.00
18 900 000	158.770	.840	5.94	0.00
19 000 000	159.610	.840	5.97	0.00
19 100 000	160.450	.840	6.00	0.00
19 200 000	161.290	.840	6.03	0.00
19 300 000	162.130	.840	6.06	0.00
19 400 000	162.970	.840	6.09	0.00
19 500 000	163.810	.840	6.12	0.00
19 600 000	164.650	.840	6.15	0.00
19 700 000	165.490	.840	6.18	0.00
19 800 000	166.330	.840	6.21	0.00
19 900 000	167.170	.840	6.24	0.00
20 000 000	168.010	.840	6.27	0.00

F CORRECTION NOT REQUIRED (not current year)

(a) Using the superimposed grid lines, determine the northing coordinate (seven significant digits) of the target in the primary zone. Also, using the printed grid lines, determine the northing coordinate of the target.

(b) Add the values of the coordinates, and divide the sum by 2 to obtain the average northing.

EXAMPLE:

Primary grid from map	5551650
Secondary grid from FO	+5552100
	11103750

$$11103750 \div 2 = 5551875$$

(c) Using the average northing and the latitude of the target at the nearest listed value, enter table 14, column N. Find the correction factor, in mils, in column C. The listed value nearest 5551875 is 560000. The correction factor is 45.598.

(d) Express the correction factor to the nearest 10 mils (45.598 50), and apply it to the OT direction using the following rules:

- When the point is transformed in the *Northern Hemisphere* from *east* to *west*, the sign is (-). When the point is transformed from *west* to *east*, the sign is (+).
- When the point is transformed in the *Southern Hemisphere* from *east* to *west*, the sign is (+). When the point is transformed from *west* to *east*, the sign is (-).

(e) If the observer is in the Southern Hemisphere, subtract the average northing coordinate from 10,000,000 before entering the table.

(6) Use the corrected direction to orient the target grid, and determine the chart data for the adjustment using standard fire direction procedures.

EXAMPLE:

East to west transformation—change sign to minus (-).

Direction (azimuth)	1,870 mils
Correction factor	+ (-50)
Corrected direction	1,820 mils

d. Observer in the Secondary Zone With Battery in the Primary Zone.

(1) **Polar plot.** A corrected direction must be determined before the target location on the firing chart is plotted. The northing coordinates of the observer's location in both zones are used to determine the average northing.

(2) **Shift from a known point.** The corrected direction must be determined before the target is plotted on the firing chart. The northing coordinates of the known point are used to determine the average northing. The target grid is oriented by use of the corrected direction. Then the shift is plotted in the usual manner.

(3) **Observer procedures.** The observer determines target location and OT direction as he does for any mission. He is not required to superimpose an additional grid over his map. When the observer sends target location, he must prefix his grid with the letter designator of the UTM grid zone in which he is located.

EXAMPLE:

ADJUST FIRE, GRID PK 515478

e. Observer in the Primary Zone With Battery in the Secondary Zone.

(1) Either zone may be designated as the primary zone. The procedures are essentially the same in both cases. The firing battery and the target or observer location must be plotted on a common grid when the firing chart is constructed. The OT direction must be corrected before the target grid is oriented for plotting subsequent corrections.

(2) Because the battery may have to fire into either zone, when the observer's grid zone is designated as primary, the following alternatives exist:

(a) The firing battery must be plotted twice on the firing chart. This requires double numbering.

(b) Two charts must be constructed.

(c) One chart covering both zones must be constructed. This requires superimposing one grid over another.

13-34. COMPUTER PROCEDURES

a. FADAC. FADAC Revision 5 Tapes, Matrix 2, contains a subroutine for grid and observer-direction transformation. The FADAC Revision 6 tape does not have this routine. If a unit is equipped with FADAC, it must use graphic procedures.

b. Battery Computer System. The SPRT;MAP entries define the coordinates, grid zone, and spheroid of the rectangle of the general area in which operations are being conducted. This rectangle is called the map modification (MAP MOD). It can be a maximum of 99,999 meters square. When the MAP MOD straddles meridian grid zones, the grid zone lying in the southwestern corner is considered the base (standard) grid zone. The MAP MOD boundaries should be specified by use of base grid zone coordinates. The BCU conducts zone-to-zone transformation. The following guidelines must be followed when entering target, observer, and other coordinates:

(1) Within the MAP MOD and in the base (standard) grid zone, short (five-digit easting and five-digit northing) coordinates may be used, and the base grid zone is assumed.

(2) Within the MAP MOD and in grid zones adjoining the base grid zone, short coordinates, expressed in the grid of the adjoining grid zone, may be used, but the grid zone must be specified. Short coordinates, expressed in the grid of the base grid zone, may be used and the base grid zone is assumed.

(3) Outside the MAP MOD and in the base grid zone, long (six-digit easting and eight-digit northing) coordinates must be used, and the base zone is assumed.

(4) Outside the MAP MOD and in grid zones adjoining the base grid zone, long coordinates must be used. They may be expressed in the grid of the adjoining grid zone, and the grid zone must be specified; or they may be expressed in the grid of the base grid zone, and the base grid zone is assumed.

Section VII HIGH-ANGLE FIRE

13-35. DESCRIPTION

a. Uses of High-Angle Fire. High-angle fire is fire delivered at elevations greater than the elevation corresponding to the maximum low-angle range for a charge. All howitzers are capable of delivering high-angle fire effectively. High-angle fire is used for firing into or out of deep defilade such as that found in heavily wooded, mountainous, and urban areas. It may also be used to fire over high terrain features near friendly troops (fig 13-53). High-angle fire may be requested by the observer on the basis of the terrain in the target area. It may also be ordered by the FDO on the basis of a terrain analysis from the battery position to the target area. The primary characteristic of high-angle fire is that an increase in elevation causes a decrease in range.

b. Limitations of High-Angle Fire. Because high-angle fire involves

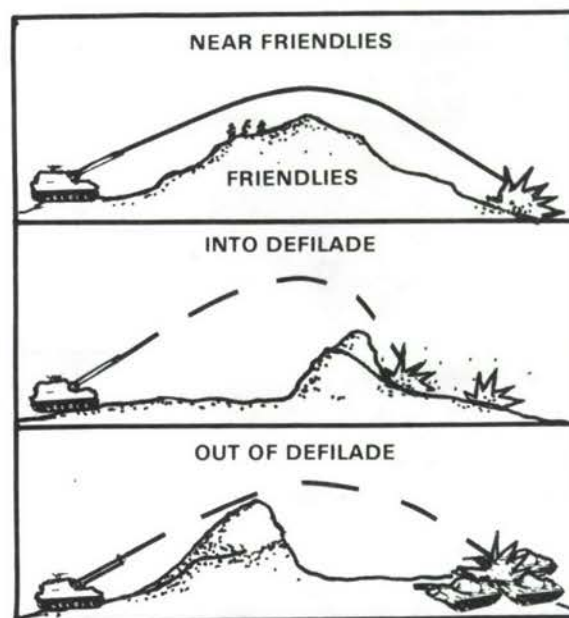


Figure 13-53. High-angle fire.

large quadrant elevations and long times of flight, it will not be as responsive as low-angle fire in meeting the immediate needs of a maneuver force. Trajectories are vulnerable to enemy detection. The long time of flight makes it difficult for the observer to identify his round. Time of flight may change drastically from round to round. Time of flight must be computed for each round during the adjustment. To further aid the observer, the FDC may announce time of flight in the message to observer.

13-36. HIGH-ANGLE GFT

The high-angle GFT (fig 13-54) consists of one rule with ballistic data for multiple charges on each side. The scales on the high-angle GFT, from top to bottom, are as follows:

a. 100/R. The 100/R scale shows the number of mils necessary to move a burst left/right or up/down 100 meters at the range determined. The scale is read to the nearest mil.

b. Range. The range scale is expressed logarithmically, in meters, and applies to all charges appearing on one side. Range increases from left to right and is read to the nearest 10 meters.

c. Elevation. Elevation is expressed in mils. It increases from right to left and is read to the nearest mil.

d. 10-Mil Site. The values on the 10-mil site scale denote the site for each 10 mils angle of site. The numbers are printed in red and are negative values. The scale increases from left to right and is visually interpolated to the nearest tenth (0.1) of a mil.

e. Drift. The values on the drift scale are in mils. The scale increases from right to left for each charge and is visually interpolated to the nearest mil.

f. Time of Flight. The time-of-flight scale is graduated in seconds and is used to determine both time of flight (nearest whole second) and VT fuze setting (drop the tenths).

Note. Because the scales increase in different directions, care must be taken in reading the high-angle GFT. On the high-angle GFT, the 100/R, drift, and time-of-flight scales increase from right to left. The range and 10-mil site scales increase from left to right. Figure 13-55 shows an aid that can be drawn on the cursor to help the computer read the scales correctly.

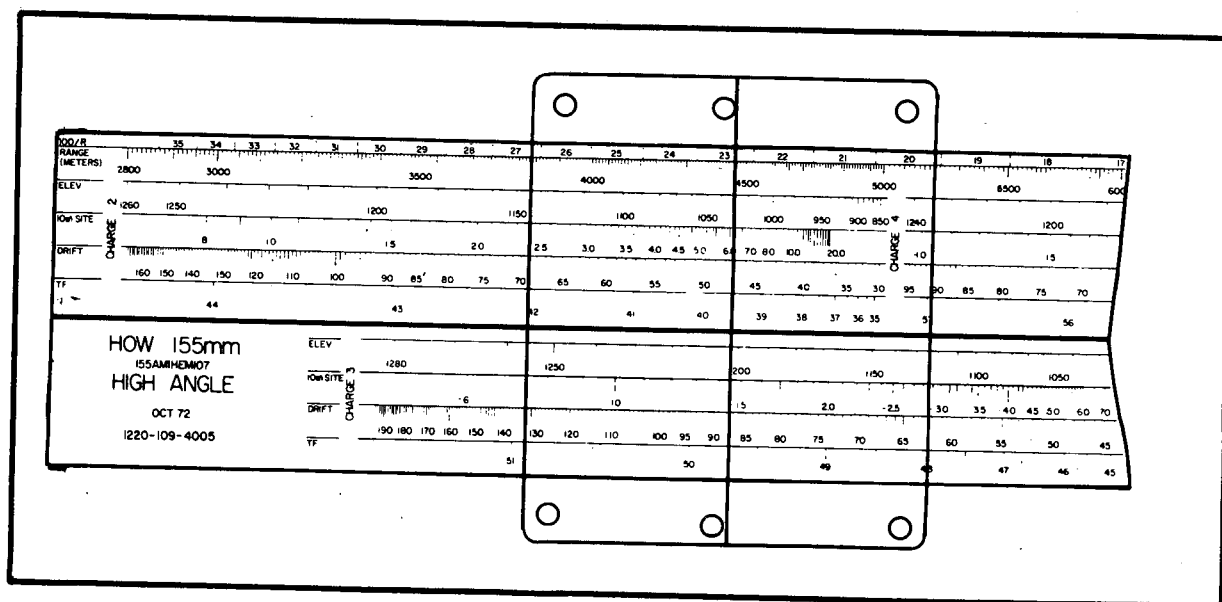


Figure 13-54. High-angle graphical firing table.

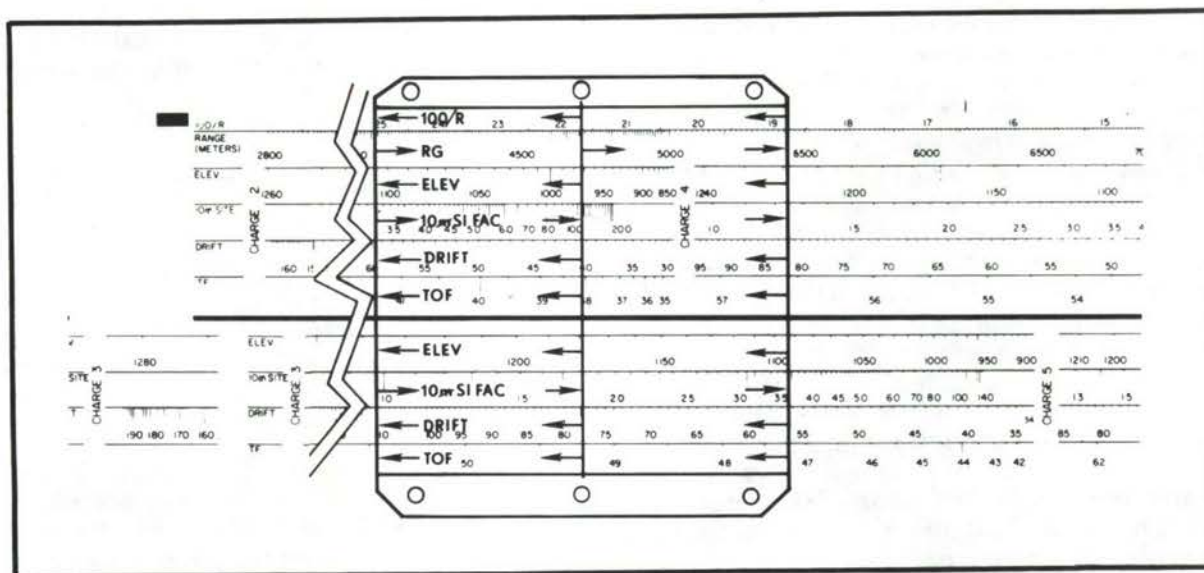


Figure 13-55. Aid for reading high-angle scales.

13-37. DUTIES OF PERSONNEL

a. The fire direction officer must do the following:

(1) Include the command **HIGH ANGLE** in the fire order.

(2) Consider high-angle fire characteristics in his selection of shell and fuze to fire in the mission.

(a) Both APICM and DPICM can be used in high-angle fire for the same type targets as in low-angle fire.

(b) The high-angle trajectory has two inherent characteristics that affect munitions selection—a *steep angle of fall* and *large probable errors*. The steep angle of fall means the projectile is almost vertical as it approaches the ground. When the high-explosive projectile bursts, the side spray contains most of the fragmentation. Since in high-angle fire the projectile is nearly vertical, the side spray is in all directions and nearly parallel to the ground (fig 13-56). Thus, shell HE, fuze Q and fuze VT, are very effective when fired high angle. The large probable error in height of burst for M564, fuze time, makes the use of this fuze impractical in high-angle fire. *Do not fire fuze time M564 high angle.*

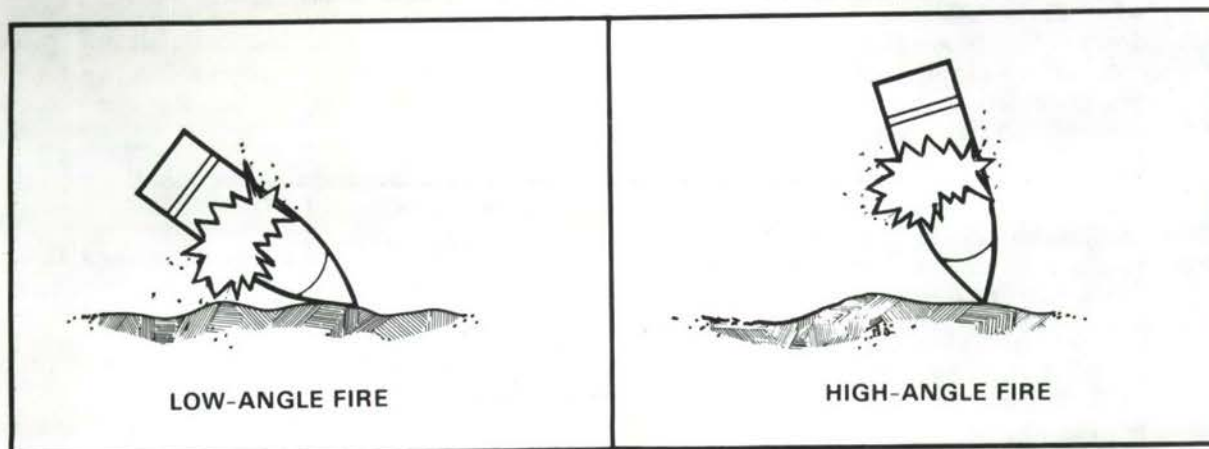


Figure 13-56. High-angle versus low-angle side spray.

b. The VCO computes and announces angle of site rather than site.

c. The computer will—

(1) **Select the charge to be fired.**

High-angle fire has two characteristics that affect the selection of the charge—a shorter range span for each charge and a range overlap between charges. The range span within which accurate fires can be delivered by a particular charge is less for high-angle fire than for low-angle fire. This may cause a problem during a high-angle fire mission, because a large observer correction may move the round outside the capabilities of the initial charge fired. This will necessitate changing charges. Changing charges during a high-angle fire mission is sometimes unavoidable, although it is not desirable. For this reason, the computer initially selects the charge that is least likely to require changing. As a guideline, he selects the lowest charge that allows for a range shift of at least 500 meters short of and 500 meters beyond the initial chart range.

EXAMPLE:

Using GFT 155-AM-2 as shown in figure 13-54 and a chart range of 4,700 meters, the computer selects charge 3, because charge 2 does not allow for a large observer correction.

(2) **Include drift corrections.** Drift is appreciably greater in high-angle fire than in low-angle fire. Because drift changes greatly for a relatively small elevation change, a correction to compensate for drift is included in each deflection to be fired. The correction is always applied to the left. The correction is determined from the high-angle GFT and is added to the sum of the chart deflection and the GFT deflection correction, if available.

(3) **Include site corrections.** If the FDO announces **INCLUDING SITE**, the computer applies site to elevation to determine quadrant elevation to be fired.

(a) Site has a relatively small effect because of the large angle of fall in high-angle fire. Site is included when angle of site is greater than ± 30 mils, when firing a high-angle registration, or when firing in a mass mission. When several batteries are to

mass on a target and only one battery is to adjust, site should be computed at the initial range for each battery. Site should be recomputed for the nonadjusting batteries when it is necessary to recompute site for the adjusting battery; for example, if the adjusting battery changes charges. Site should also be recomputed for an individual nonadjusting battery if it changes charges. When adjustment is required before massing and when only one battery is to adjust, normally, the battery that is most centrally located should be designated as the adjusting battery to minimize large differences in range for the nonadjusting batteries.

(b) If site is to be used, the FDO announces **INCLUDE SITE** in the fire order. Since one of the criteria for including site is an angle of site greater than ± 30 mils, the FDO may have to wait for the VCO to compute and announce angle of site. In this situation, the FDO issues a fire order and later supplements it with the command **INCLUDE SITE**.

(4) **Announce high angle.** Announce **HIGH ANGLE** as a special instruction when sending initial fire commands to the guns.

d. The RATELO may announce **TIME OF FLIGHT** in the message to observer and will announce **SPLASH** for each round.

13-38. HE HIGH-ANGLE MISSIONS

a. High-Angle Mission Computed Without a GFT Setting.

(1) Upon receipt of the call for fire requesting a high-angle method of engagement, the FDO issues the fire order (fig 13-57).

(2) The computer announces the initial fire commands (fig 13-57).

(3) The RATELO announces the message to observer on the basis of the fire order (fig 13-57).

(4) The chart operator determines chart data.

(5) The VCO announces angle of site greater than ± 30 mils, and the FDO amends the fire order to include site.

RECORD OF FIRE															
Observer <u>B3H26</u>		CALL FOR FIRE <u>AT</u> PFE/IS/S _____ Tgt _____			TGT <u>565</u> BTRY <u>355</u>					△ FS 100/R /R 20/R HOB Corr					
Grid: _____		Polar: Dir _____ Dis _____ U/D _____ VA _____			Shift _____ Dir _____ L/R _____ +/- _____ U/D _____					Si ÷ 10 10m Si HOB Corr					
FIRE ORDER <u>SPEC CORR ④</u>										Df Corr		Si			
INITIAL FIRE COMMANDS		☒ MF BTRY ADD #3 ①			Rg <u>< 640</u>		Cht Df <u>3402</u>			EI					
Sp Instr <u>HA</u>		Sh		Lot		Chg		Fz		Ti		Df		QE	
MTO <u>G, ④</u> , TGT AC <u>7827</u>		<u>1(250)</u>		PER		TF		in Eff		Ammo Exp					
SUBSEQUENT FIRE COMMANDS															
Tgt	Location	Priority	Firing Unit	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si ()	EI	QE	Exp Type
<u>DIR</u>															
<u>6390</u>															
Btry <u>A</u>		DTG		Tgt		Replot Grid		Replot Alt							
DA FORM 4504 1 OCT 78															

Figure 13-57. High-angle fire order, initial fire commands, and message to observer.

(6) The computer determines and announces initial firing data (fig 13-58) by—

(a) Selecting the charge. The computer places the MHL over the chart range and determines that the charge to fire is charge 4.

(b) Determining deflection. The computer applies drift corresponding to elevation to determine deflection.

(c) Determining quadrant elevation.

- The computer determines the elevation to fire from the graphical firing table.

- The computer determines site by—
Determining the 10-mil site factor (negative value) from the graphical firing table.

Dividing the announced angle of site by 10 and multiplying that quotient by the 10-mil site factor.

RECORD OF FIRE															
Observer <u>B3H26</u>		CALL FOR FIRE <u>AT</u> PFE/IS/S _____ Tgt _____			TGT <u>565</u> BTRY <u>355</u> VI <u>+210</u> SI <u>+32</u>					△ FS 100/R <u>15</u> /R 20/R HOB Corr					
Grid: <u>597 389</u>		Polar: Dir _____ Dis _____ U/D _____ VA _____			Shift _____ Dir _____ L/R _____ +/- _____ U/D _____					Si ÷ 10 + 3.2 10m Si <u>3.41</u> HOB Corr					
FIRE ORDER <u>SPEC CORR, ④</u> , INCLUDE SITE										Df Corr <u>L49</u>		Si <u>-11</u>			
INITIAL FIRE COMMANDS		☒ MF BTRY ADD #3 ①			Rg <u>6640</u>		Cht Df <u>3402</u>			EI <u>1108</u>					
Sp Instr <u>HA</u>		Sh		Lot		Chg <u>4</u>		Fz		Ti		Df <u>3451</u>		QE <u>1097</u>	
MTO <u>G, ④</u> , TGT AE <u>7828</u>		<u>1(250)</u>		PER		TF <u>53</u>		<u>④ FZ VT</u>		in Eff		Ammo Exp <u>①</u>			
SUBSEQUENT FIRE COMMANDS															
Tgt	Location	Priority	Firing Unit	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr ()	Df Fired	Chart Rg	HOB Corr	Si ()	EI	QE	Exp Type
<u>DIR</u>															
<u>6390</u>															

Figure 13-58. High-angle initial firing data.

The computer determines the quadrant elevation by algebraically adding site to elevation.

Note. High-angle site always takes the sign opposite angle of site.

(d) Announcing fire commands.

(7) The RATELO announces SHOT and SPLASH to the observer.

(8) Subsequent fire commands are computed. Drift is determined and applied to every deflection computed (fig 13-59).

(9) When hasty or special corrections are being used, the sign for high-angle quadrant correction is reversed.

RECORD OF FIRE																	
Observer <u>B3H26</u>		CALL FOR FIRE		Tgt		TGT <u>565</u>		$\triangle$ FS									
Grid: <u>597 389</u>		<u>AF/FE/IS/S</u>				BTRY <u>355</u>		100/R <u>15</u>									
Polar: Dir		Dis		U/D		VA		/R									
Shift		Dir		L/R		VT $\frac{3}{E}$ +/-		20/R									
COMPANY WATER POINT		HA		VT $\frac{3}{E}$ +/-		U/D		HOB Corr									
FIRE ORDER <u>SPEC CORR, (4), INCLUDE SITE</u>								Df Corr		Si <u>-11</u>							
INITIAL FIRE COMMANDS								MF BTRY ADJ #3 (1)		Rg <u>6640</u>		Cht Df <u>3402</u>		EI <u>1108</u>			
Sp Instr <u>HA</u>				Sh		Lot		Chg <u>4</u>		Ft		Ti		Df <u>3451</u>		QE <u>1097</u>	
MTO <u>G, (4), TGT AC 7827</u>				<u>41 (250)</u>		Pgr		TF <u>53</u>		<u>(4) FZ VT</u>		in Eff		Ammo Exp <u>(1)</u>			
Tgt	Location	Priority	Firing Unit	SUBSEQUENT FIRE COMMANDS													
Dir, MF Sh, Fz	Dev	Rg	HOB Corr	MF, Sh, Chg, Fz	FS Corr	Ti	Chart Df	Df Corr (-)	Df Fired	Chart Rg	HOB Corr	Si (-/1)	EI	QE	Exp	Type	
DIR	R100	-200					3393	L52	3445	6420		-11	1130	1119	(2)	QV	
6390	L30	+50	FFE	BTRY (4) FZ VT	(53.0)		3397	L51	(3448)	6480		-11	1124	(1113)	BTRY	DATA	
				SPEC CORR													
				R PLT	54.0		3448	L18	3466			+29	1113	1142	(8)		
				C PLT	53.0		3448	R4	3444			+1	1113	1114	(10)		
				L PLT	52.0		3448	R22	3426			-32	1113	1091	(24)	VT	
			EM	EM													
				FZ SETTING DETERM FROM EL (EX RPLT QE)				DF CORR FROM SPEC CORR WORK SHEET				DF CORR FROM SPEC CORR WORK SHEET					
				1142 - (C) SITE = EL 1153													
				COMPANY NEUTRALIZED EST 40 CAS													

PLATOON	GUN NUMBER	POSITION LATERAL CORRECTION (LEFT/RIGHT)	100/R (GRAPHICAL FIRING TABLE)	DEFLECTION		RANGE		MUZZLE VELOCITY		POSITION RANGE CORRECTION		TOTAL RANGE CORRECTION		POSITION QUADRANT ELEVATION CORRECTION		CORRECTED RANGE (h) $\approx$ 10 METERS - INITIAL RANGE	TIME TO FIRE FUZE SETTING $\sim$ (i)
				POSITION DEFLECTION CORRECTION (LEFT/RIGHT)	PLATOON COMPARATIVE VELOCITY ERROR (INCREASE/DECREASE)	MUZZLE VELOCITY UNIT CORRECTION FACTOR (TABLE F, APPROPRIATE FT)	MUZZLE VELOCITY RANGE CORRECTION	POSITION RANGE CORRECTION (FORWARD -1 (BACK +1))	POSITION QUADRANT ELEVATION CORRECTION (COLUMN 5, TABLE F, APPROPRIATE FT)								
				(a) - (b)	(c) - (d)	(e) - (f)	(g) - (h)	(i) - (j)	(k) - (l)								
		a	b	c	d	e	f	g	h	i	j	k					
		5 METERS	1 MIL	1 MIL	0.1 METER PER SECOND	0.1 METER	1 METER	5 METERS	1 METER	1 MIL	10 METERS	0.1					
R	1																
	2	L120	15	L18	I1.0	-27.0	-27.0	-235	-262	+29							
C	3	T															
	4	R30	15	R4	0			-5	-5	+1							
L	5																
	6	R150	15	R22	DO.8	32.6	+26.1	+265	+291	-32							

REVERSE OF DA FORM 4757 SEP 84 EDITION OF OCTOBER 1978 IS OBSOLETE

Figure 13-59. Subsequent high-angle adjustments.

b. High-Angle Registration. If the battery position is in defilade or if most of the targets are in defilade and the tactical situation will allow it, a high-angle registration may be conducted. Only the impact portion of a precision registration or an MPI registration can be conducted with high-angle fire because of the large PEHB with the time fuze (M564).

(1) **True adjusted elevation.** The adjusted elevation, determined from a high-angle impact registration, often includes a false site. This false site is caused by the relationship of the comp site to total site. Comp site is a function of elevation. In low-angle fire, *small* changes in elevation cause *small* changes in comp site. On the other hand, in high-angle fire, *small* changes in elevation cause *large* changes in comp site. In a high-angle registration, the comp site determined at the initial elevation and applied throughout the mission often differs substantially from the comp site corresponding to the adjusted elevation. This false comp site, when added to the angle of site, produces a false site. To provide accurate data, the FDC must determine the true site and subtract it from the adjusted QE to compute the true adjusted elevation. To determine the true site, successive approximation is used. The procedures for successive approximation are as follows:

(a) At the conclusion of a registration, the computer subtracts the site fired from the adjusted QE to determine the first apparent elevation.

EXAMPLE:

Adj QE	1062
Si fired	- (-5)
First app el	1067
(1062 - (-5) = 1067)	

(b) The computer then determines a new site by multiplying the angle of site divided by 10 by the 10-mil site factor corresponding to the first apparent elevation. This yields a new site called the first apparent site. If the first apparent site agrees within 1 mil of the site fired, the first apparent site is the true site.

EXAMPLE:

Angle of si - 10	= +1.5
10m si factor	= -4.6
First app si	= -6.9 $\approx$ -7

(c) If the first apparent site is not within 1 mil of the site fired, the computer will continue the same process to determine a second apparent elevation. To compute a second apparent site, he will use the 10-mil site factor corresponding to the second apparent elevation and the angle of site. If the second apparent site is within 1 mil of the previously computed site, the second apparent site is the true site.

EXAMPLE:

Adj QE - 1st app si	= 2d app el
1062 - (-7)	= 1069
10m si factor $\approx$ el 1069	= -4.5
2d app si = -4.5 $\times$ +1.5	= -6.75 $\approx$ -7

(d) If the second apparent site is not within 1 mil of the previously computed site, the computer will continue the process until the last computed site is within 1 mil of the previously computed site. The last site computed is the true site.

(e) To compute the true adjusted elevation, the computer will subtract the true site from the adjusted QE.

EXAMPLE:

The second apparent site is within 1 mil of previously computed site. This is true site (-7).

Adj QE	1062
True si	- (-7)
True adj el	1069

(2) High-angle GFT setting.

(a) The GFT settings for high-angle fire are written in the same manner as those for low-angle fire.

(b) The high-angle GFT setting is constructed on the GFT by placing the MHL over the adjusted elevation for the charge and drawing a range gage line through the GFT setting range on the range scale (fig 13-60). The MHL becomes the elevation gage line, and all data except range and 100/R are read under the manufacturer's hairline. The GFT deflection correction and charge are recorded on the cursor.

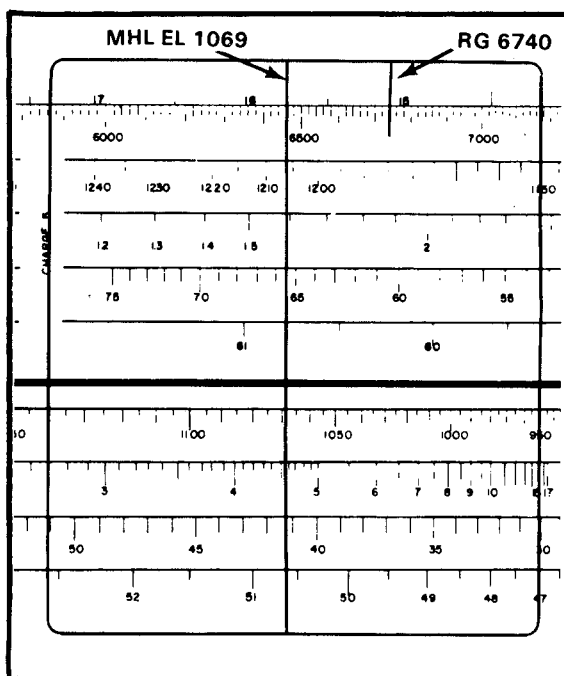


Figure 13-60. High-angle GFT setting.

(3) **High-angle registration transfer limits.** The registration correction for a registered charge will transfer to all ranges and charges in that powder model.

c. High-Angle Mission Computed With a GFT Setting. A high-angle mission computed with a GFT setting applied is computed as described in paragraph 13-37a, except that data are read under the elevation gage line (MHL) (fig 13-61).

Note. The sign for column *i* reverses for high angle.

13-39. DPICM HIGH-ANGLE REGISTRATION

a. A registration with DPICM (M483A1) is conducted in the self-registration mode.

b. If the terrain in the target and/or battery area indicates that high-angle fire must be used, a high-angle high-burst registration can be conducted by use of the M577 fuze. (It has a small height-of-burst probable error.) This type of registration is conducted with the DPICM projectile in the

self-registration mode. The procedures are the same as those for a low-angle high-burst registration with the following exceptions:

(1) A minimum of 4 PEHB (TFT, table G [fig 13-62]) or 50 meters, whichever is greater, is added to the orienting point ground altitude.

(2) In a high-burst high-angle registration, the fuze setting to fire is the fuze setting corresponding to elevation plus comp site. Comp site in high-angle fire will be a

CHARGE
4G

TABLE G
SUPPLEMENTARY DATA

FT 155-AM-2

PROJ. HE, M107
FUZE, PD, M557

1	2	3	4	5	6	7	8	9	10	11	12	13
R A N G E	E L E V	PROBABLE ERRORS					ANGLE OF FALL	COT ANGLE OF FALL	TML VEL	MO	COMP SITE	
		R	D	FUZE M564							+1 MIL SITE	-1 MIL SITE
				HB	TB	RB						
M	MIL	M	M	M	SEC	M	MIL		M/S	M	MIL	MIL
0	0.0	4	0				0		316	0	0.000	0.000
500	25.4	4	0				26	39.4	308	3	0.001	0.000
1000	51.7	5	1	1	0.06	18	53	19.1	301	13	0.002	-0.002
1500	78.9	7	1	2	0.07	19	83	12.3	296	30	0.005	-0.005
2000	107.0	8	1	2	0.07	21	113	9.0	290	54	0.010	-0.010
2500	136.2	9	2	3	0.08	22	146	6.9	285	87	0.017	-0.016
3000	166.6	11	2	4	0.08	23	180	5.6	280	129	0.026	-0.024
3500	198.4	12	2	5	0.09	25	217	4.6	276	181	0.038	-0.035
4000	231.7	14	3	7	0.09	26	256	3.9	272	244	0.054	-0.049
4500	267.0	16	3	8	0.10	27	297	3.3	268	319	0.075	-0.068
5000	304.5	18	4	10	0.11	29	341	2.9	265	410	0.103	-0.093
5500	344.9	20	4	12	0.11	30	389	2.5	262	517	0.142	-0.125
6000	389.0	23	5	14	0.12	32	441	2.2	259	647	0.199	-0.171
6500	438.3	25	5	17	0.13	33	500	1.9	257	804	0.287	-0.238
7000	495.5	28	6	20	0.14	35	566	1.6	255	1002	0.445	-0.347
7500	566.7	31	7	24	0.15	37	647	1.4	254	1269	0.831	-0.553
8000	677.4	34	8	32	0.17	39	768	1.1	255	1714		-1.191
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
8000	886.8	37	9	46	0.19	38	977	0.7	260	2597		2.216
7500	996.2	35	10	53	0.21	35	1078	0.6	263	3042	-1.849	1.576
7000	1066.3	32	10	57	0.21	32	1142	0.5	265	3309	-1.461	1.377
6500	1122.1	30	9	60	0.22	30	1193	0.4	267	3508	-1.301	1.255
6000	1169.8	27	9	63	0.22	27	1238	0.4	268	3665	-1.208	1.183
5500	1211.6	24	9	65	0.22	24	1279	0.3	269	3793	-1.146	1.131
5000	1248.5	21	8	67	0.23	21	1317	0.3	269	3897	-1.101	1.092
4500	1280.7		8	69	0.23	18	1355	0.2	269	3980	-1.066	1.061

Figure 13-62. Table G.

relatively large number. Comp site is determined by entering the TFT, table G, column 12 or 13 (fig 13-62), to the nearest 500 meters in range listed and extracting the comp site factor for a ± 1 mil angle of site. The angle of site is multiplied by the comp site factor. The result is comp site. The comp site is applied to the elevation determined from the high-angle graphical firing table. The manufacturer's hairline is moved over the value of elevation plus comp site and read from the time-of-flight scale to the nearest 0.1 fuze setting increment.

Note. The difference between the fuze setting and the time of flight does not vary more than 0.1 increment on the graphical firing table.

(3) Drift and elevation are determined from the high-angle graphical firing table.

(4) Site is determined by use of the 10-mil site factor corresponding to the adjusted elevation multiplied by the new angle of site determined.

c. The adjusted elevation for a high-angle high-burst registration is determined in the same manner as in a low-angle high-burst registration. However, the new angle of site is based on the altitude of the mean burst location.

d. The adjusted time is determined in the same manner as in a low-angle high-burst

registration. The adjusted time is used to determine a total fuze correction, which is applied to the fuze setting corresponding to the adjusted elevation when firing with a GFT setting. In solving a concurrent met to determine position constants, the total fuze correction is used as a known correction. The total fuze correction is determined by subtracting the time corresponding to elevation plus comp site from the time fired.

13-40. COMPUTER PROCEDURES

a. **FADAC.** The method used for determining firing data in high-angle missions is the same as that used for low-angle missions with the following exceptions:

(1) The FADAC operator enables the high-angle function.

(2) The FADAC operator does designate a charge.

b. **BCS Procedures.** The BCS will use a high-angle trajectory—

(1) When the BCU operator selects the high-angle function.

(2) When the BCS encounters a mask violation. The BCS will automatically attempt a high-angle solution if an attempted low-angle solution encounters a mask violation.



CHAPTER 14

EMERGENCY PROCEDURES/
OBSERVED FIRING CHARTS

ImmEDIATE delivery of supporting fires must not be delayed because of incomplete survey or the lack of suitable maps. When survey control and maps are not available, emergency procedures, to include construction of an emergency firing chart, construction of an observed firing chart, or use of the M10/M17 plotting board, can be used to develop effective firing data. An emergency firing chart is used when immediate attack of a target is required,

when a GFT setting is not available, and when there is no time to register. The FDC may register later and develop the observed firing chart. The M10/M17 plotting board is normally used by the firing battery officer at the weapon positions to convert observer data to range and deflection for the computation of firing data. This emergency procedure is used when the battery FDC is not available and other technical fire direction means are not provided.

Section I.
OBSERVED FIRING CHARTS

14-1. EMERGENCY FIRING CHARTS

a. The battery emergency firing chart is an observed firing chart constructed without a registration. The battery center is assigned an assumed grid and an assumed altitude; for example, grid 20004000, altitude 400 meters. The grid sheet is appropriately numbered on the basis of the assumed battery location. A deflection index is constructed on the basis of the battery azimuth of lay. The relative locations of the battery and a target can be determined by the adjustment of fire.

b. The observer's call for fire may include **MARK CENTER OF SECTOR** as the target location. The FDO determines the direction of fire and a safe range on the basis

of the tactical situation and announces **IGNORE SITE AND DEFLECTION CORRECTION** in the fire order. The chart operator determines the data for the initial round from the estimated direction and range to the center of the battery's sector. To help the observer locate the first round, the unit may fire white phosphorous, smoke, or a high airburst of high explosive or white phosphorous. Subsequent firing data are based on the observer's corrections. Fire direction procedures in the conduct of fire are the same as those used with a surveyed firing chart. After the mission has been completed, the observer may use the target as a known point in reporting other target locations. If the observer wishes to use the target as a known point, the FDC must plot the target location on the firing chart.

c. As long as the ballistic variables of weather, materiel, and ammunition remain relatively constant, any previously fired target may be refired with the same firing data. If the ballistic conditions do not remain constant, inaccuracies will develop in subsequent firings. The battery should conduct a registration as soon as possible to provide a means of determining subsequent ballistic changes and to increase the accuracy of relative locations.

d. The FDC should plot the targets located by fire on the firing chart to provide an additional means of target location if requested by the observer or directed by the fire direction officer. The last pinhole marking a target located by fire will provide sufficient accuracy and should be noted with a red tick mark and a target number. In shifting from the red tick mark, do not include site or deflection correction, because they were accounted for in the final pin location. Include computation for site if an up or down correction is given.

14-2. CONSTRUCTION OF AN EMERGENCY OBSERVED FIRING CHART

The FDC constructs the emergency observed firing chart on any suitable flat surface to convert observer corrections to firing data. The following steps are used to construct the emergency observed firing chart.

a. *Representing the Battery Location.* Place the RDP in the middle of the surface chosen to represent the emergency firing chart. The vertex will represent the battery center. Place a pin there.

b. *Establishing the Azimuth of Fire and Common Deflection.* Without moving the RDP, establish the primary deflection index by placing a pin opposite the graduation on the arc of the RDP (fig 14-1).

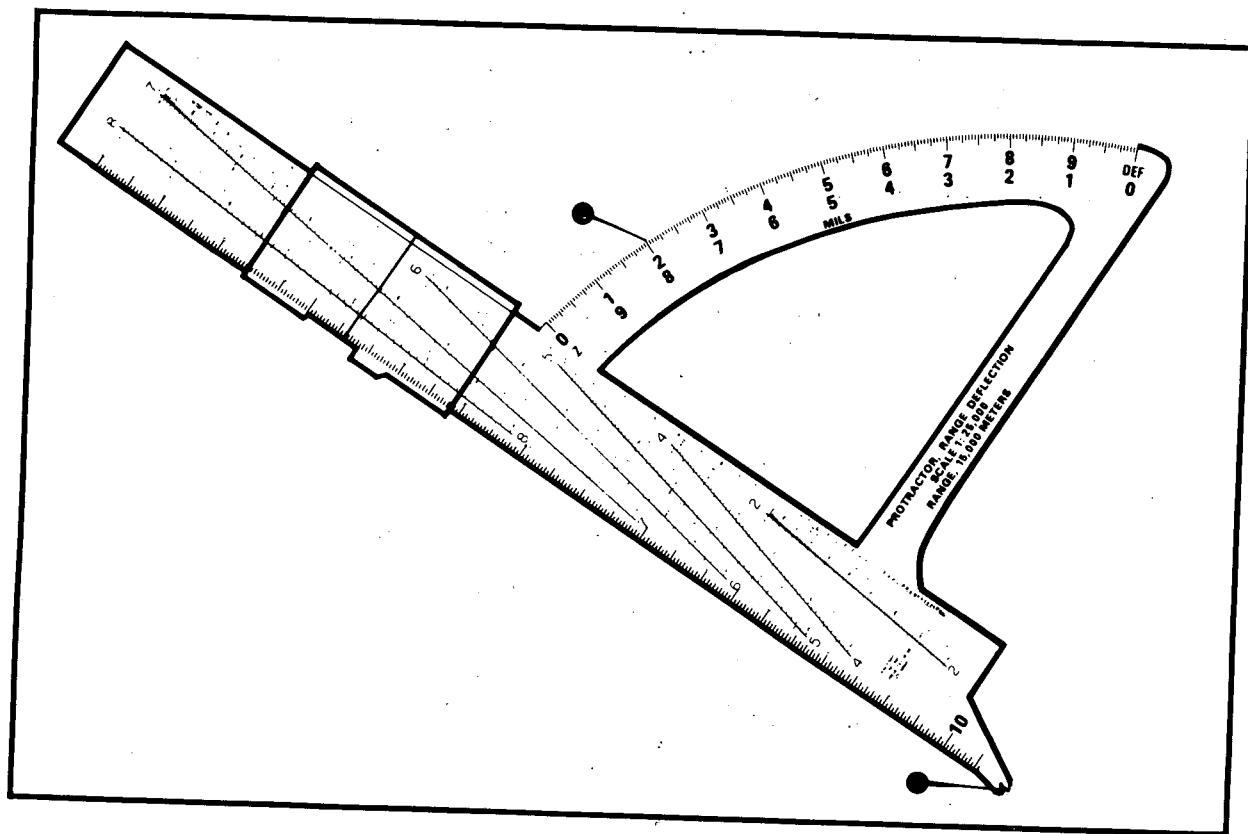


Figure 14-1. Establishing the primary deflection index.

c. Plotting the Range to the Center of Sector or Target Location. Without moving the RDP, place a pin opposite the range to the center of sector or at the location of the target as reported by the observer (fig 14-2).

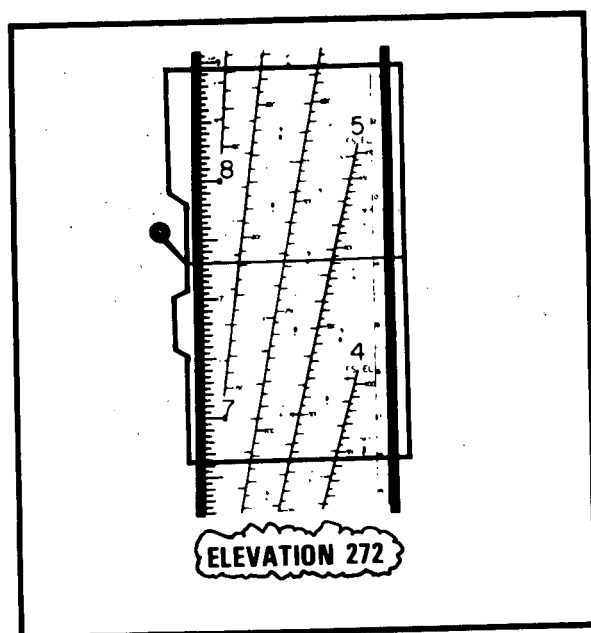


Figure 14-2. Pin location of initial round.

d. Establishing a Grid North Index.

(1) Center a target grid over the pinhole to the center of sector or the target location.

(2) Align the 0-3200 line of the target grid with the left edge of the arm of the range-deflection protractor. The arrow on the target grid should face away from the vertex of the RDP, since the left edge of the RDP is pointing along the azimuth of lay (fig 14-3).

(3) Place a pin opposite the graduation on the target grid corresponding to the azimuth of lay (fig 14-3).

Note. Notice that this pin now represents grid north index, since the 0-3200 line and the arrow on the target grid coincide with the edge of the RDP, which represents the azimuth of lay. In other missions, depending on the azimuth of lay, the pin may have to be moved to establish this index.

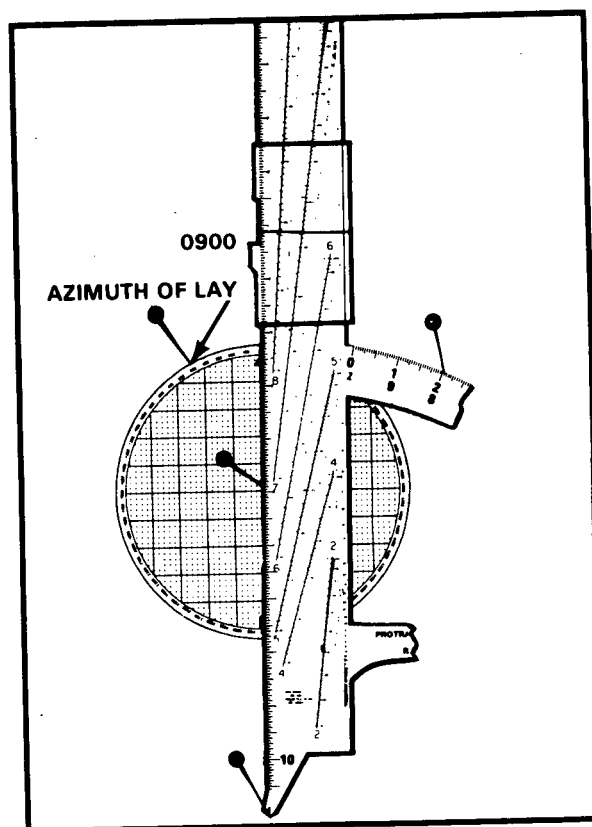


Figure 14-3. Centered target grid.

e. Orienting the Target Grid. Rotate the target grid until the announced OT direction is opposite the north index (fig 14-4). Plot subsequent corrections in the same manner as those on surveyed firing charts.

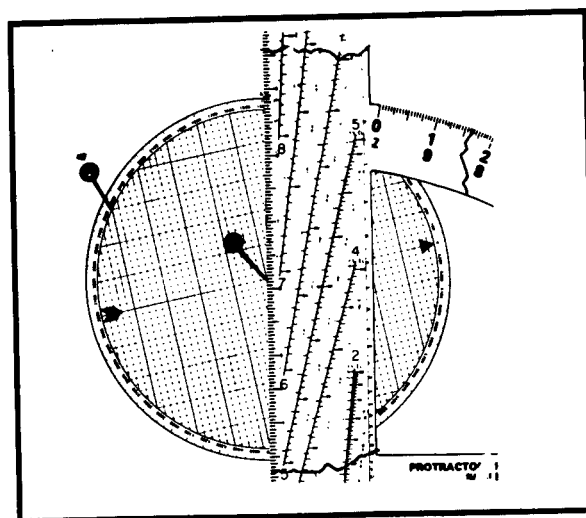


Figure 14-4. Oriented target grid.

f. Plotting the Refinement. After plotting the end of mission refinement corrections from the observer, determine the final chart range and deflection.

g. Tick Marking the Final Pin Location. The tick mark for the target is constructed in the same manner as for any other target located by firing (red). It is not a permanent location on the firing chart, because it only temporarily establishes the relative location of the target point. Firing an occasional check round will enable the FDC to keep the relative location updated.

h. Establishing a Permanent Battery Location. At the pin representing the battery, draw a tick mark and label it by use of standard procedures.

i. Constructing a Grid North Index for the Target. Since the observer may wish to shift from this new known point, establish a grid north index as follows:

(1) Recenter the target grid over the location of the target tick mark. Place the edge of the RDP against the pin. Align the 0-3200 line of the target grid with the arrow end pointing away from the vertex along the edge of the range-deflection protractor.

(2) Determine the azimuth to the final pin location by converting the final chart deflection to an azimuth.

EXAMPLE:

Initial df (3200) - final df (3238) = L38 df change

Az of lay (1700) - df change (L38) = 1662

Since this is the direction represented by the edge of the RDP, use the same procedure that was demonstrated earlier in this paragraph; that is, place a pin opposite the graduation on the target grid corresponding to the azimuth to the target (1662).

Note. This pin now represents a grid north index, since the 0-3200 line and arrow on the target grid coincide with the edge of the RDP, which represents the azimuth to the final pin location.

j. Establishing Permanent Deflection Indexes. At the deflection index pin, using normal plotting techniques, construct a permanent deflection index for the plotted battery position.

Note. If it appears that the unit will be remaining in the same position for a sustained period of time, transfer operations to a surveyed firing chart as soon as possible. Get off the emergency chart as soon as possible.

14-3. BATTERY OBSERVED FIRING CHARTS

Battery observed firing charts are constructed when time permits the unit to fire a registration. Normal procedures and sequence in the construction of a battery observed firing chart are as follows:

a. Have an observer select a registration point near the center of the battery's zone of fire.

b. Arbitrarily assign this registration point an assumed altitude and assumed grid coordinates. Plot this location on the firing chart. For simplicity, assign the point a grid intersection; for example, grid 20004000, altitude 400 meters.

c. Conduct a precision registration. Include fuze time if possible.

d. Determine the adjusted data.

e. From the adjusted data, determine the direction (azimuth) and distance (range) from the registration point to the battery.

f. Polar plot the battery center from the registration point.

14-4. DETERMINATION OF DIRECTION FOR POLAR PLOTTING

a. At the completion of the registration, the firing battery measures the azimuth or the orienting angle (if an orienting line has been established).

b. When an orienting line has not been established, the azimuth of fire is measured after the registration. The battery center is

polar plotted on the back azimuth of the measured azimuth. Drift should be subtracted from this back azimuth before the battery is plotted.

c. When an orienting line has been established, the battery will measure the orienting angle after the registration. The azimuth of fire is computed (azimuth of orienting line minus the orienting angle equals the azimuth of fire). The battery center is polar plotted from the registration point as in paragraph *b* above.

14-5. DETERMINATION OF RANGE AND ALTITUDE-IMPACT REGISTRATION

a. When maps and survey data are not available, the determination of accurate site is impossible. Every effort must be made to determine approximate site. If the determination of an approximate site is not feasible, site is assumed to be 0.

b. The range for polar plotting the firing unit location center grid is the range corresponding to the adjusted elevation (adjusted QE minus the site and any height-of-burst correction 20/R. Place the manufacturer's hairline of the GFT over the adjusted elevation, and read the range under the hairline.

c. Estimate the VI between the battery and the registration point if possible. Use the estimated VI in determining site by *successive approximation*. Determine the battery altitude in the following manner:

(1) Determine the range corresponding to the adjusted quadrant.

(2) Use the determined range and the estimated VI to compute the first apparent site.

(3) Apply the site to the adjusted QE to determine an elevation.

(4) Determine the range corresponding to the determined elevation.

(5) Use the range corresponding to the determined elevation and the estimated VI to compute the second apparent site.

(6) Continue successive approximation until the site agrees with or is within 1 mil of the previously computed site. Use the last site computed to determine the adjusted elevation. Use the adjusted elevation to determine the polar plot range.

(7) Apply the VI to the assumed altitude of the registration point to determine the altitude of the battery.

14-6. DETERMINATION OF RANGE AND ALTITUDE-TIME REGISTRATION, SITE UNKNOWN

a. The major sources of errors in range in an observed firing chart, impact registration, are the lack of an accurate site and nonstandard conditions. If the site is unknown or incorrect, the derived adjusted elevation is in error by the amount of error in site. Determining the polar plot range from false elevation produces a false range. However, the effect of site on fuze setting is less severe. Therefore, the adjusted time can be used as a good indicator of the adjusted elevation and the polar plot range.

b. Derive a site by subtracting the elevation corresponding to the adjusted time (minus any position fuze correction, if any) from the adjusted quadrant elevation. Using the graphical site table, determine the VI by multiplying the polar plot range by the derived site. Determine range by placing the MHL of the GFT over the adjusted time and reading range from beneath the MHL on the RG scale. Determine the altitude of the battery by applying the VI to the assumed altitude of the registration point.

c. When an average fuze correction is known, increase the accuracy of site and elevation by determining the adjusted elevation in the following manner:

(1) Subtract the average fuze correction from the adjusted time.

(2) Read the adjusted elevation corresponding to the corrected adjusted time.

14-7. DETERMINATION OF SITE BY FIRING (XO'S HIGH BURST)

An approximate site approaching survey accuracy may be determined from a modified high-burst registration fired after a precision registration.

a. Fuze setting (time) for a given charge is a function of elevation plus comp site. Therefore, if the fuze setting is kept constant and the QE varies, the elevation plus comp site to each of the resulting points of burst is constant.

b. After a registration, fire a group of rounds with the adjusted time but with a QE large enough to raise the point of burst. The raised point of burst should be visible from the battery location; therefore, the angle of site can be measured. Subtract the measured angle of site to the burst from the quadrant elevation. The result is the elevation plus comp site to the burst ($QE = el + CAS + \text{angle of site}$). The elevation plus comp site corresponds to the fuze setting fired (adjusted time). It is equal to the elevation plus comp site to the registration point. Use the angle of site and the range corresponding to the adjusted elevation to determine the VI and site to the registration point.

c. The procedure for conducting the XO's high-burst is as follows:

(1) After the time portion of the registration, the following command is sent to the firing battery. **OBSERVE HIGH-BURST REGISTRATION, MEASURE ANGLE OF SITE, 3 ROUNDS, ADJUSTED DEFLECTION (so much), ADJUSTED TIME (so much), ADJUSTED QUADRANT ELEVATION (so much).** The XO estimates the increase in site necessary to cause the bursts to be visible from the battery position and adds it to the announced quadrant elevation. He then has the registering piece fire three rounds at the adjusted time, the adjusted deflection, and the increased quadrant elevation. The XO measures the angle of site to each burst with an aiming circle set up in the vicinity of the registering piece. He then reports the average observed angle of site and the QE fired.

(2) The FDC determines the site to the registration point, the adjusted elevation, and the VI between the battery and the registration point as follows:

(*a*) Determine the elevation plus comp site for the XO's high burst by subtracting the average angle of site from the QE fired. The elevation plus comp site determined is the elevation plus comp site to the registration point.

(*b*) Determine the angle of site to the registration point by subtracting the elevation plus comp site from the adjusted QE to the registration point.

(*c*) Using the C- and D-scales of the GST, determine the VI between the battery and the registration point by multiplying the angle of site ((*b*) above) by the range to the registration point in thousands of meters to the nearest 10 meters.

(*d*) Using the appropriate site-range scale of the GST, determine the site to the registration point by dividing the VI by the range to the registration point. Do not move the GST cursor from the position it was in when the VI was determined in (*c*) above.

(*e*) Derive the adjusted elevation by subtracting the site ((*d*) above) from the adjusted quadrant elevation.

d. The "got minus asked for" rule explains the procedures for the XO's high burst (fig 14-5) in computing the angle of site.

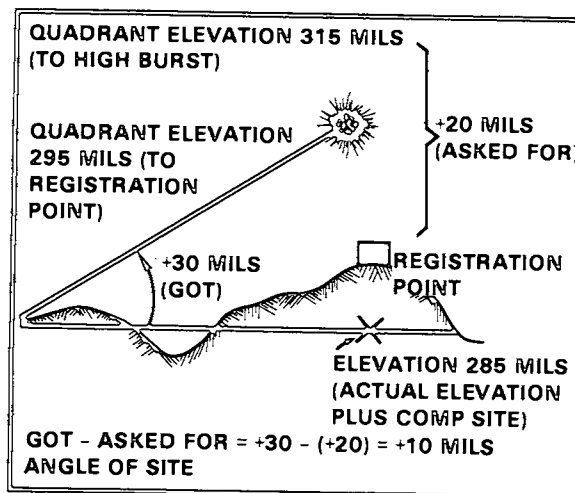


Figure 14-5. Executive officer's high burst.

14-8. GFT SETTINGS

Construct the GFT setting by placing the MHL over the chart range (polar plot range) and drawing the elevation gage line through the adjusted (derived) elevation and the time gage line through the adjusted time. Construct the elevation and time gage lines even though they may be on the manufacturer's hairline.

14-9. OBSERVED FIRING CHART WITH INCOMPLETE SURVEY

A position area survey may be used in conjunction with the observed firing chart until the surveyed firing chart is available. The part of the chart established by firing must be plotted to the same scale as that part obtained by survey.

14-10. CONSTRUCTION OF OBSERVED FIRING CHART-POSITION AREA SURVEY ONLY

The procedure for constructing a battalion observed firing chart on the basis of the registration of one battery having completed a position area survey is as follows:

- a. Establish a common orienting line (OL) for the battalion.
- b. Starting at any point, run a traverse to locate all battery positions horizontally and

vertically in relation to each other and to establish common directional control for all orienting lines.

c. Plot the battery positions, altitudes, and orienting lines on tracing paper to the same scale as that of the chart to be used. This overlay, including the measured grid azimuth of the orienting lines, constitutes the position area survey as known in the fire direction center.

d. Register one battery on the registration point. From the adjusted data, start the observed firing chart by plotting the registered battery.

e. Derive the azimuth of fire from the measured orienting angle of the registering battery. Use the derived azimuth of fire for the direction of fire of the battery on the overlay.

f. Orient the overlay so the battery center of the registering battery is over the same location on the chart. Rotate the overlay until the direction of fire lines on the chart and the overlay coincide. Pinprick the locations of the nonregistering batteries, and then label them with the proper altitudes in relation to the registering battery.

g. Measure the azimuth from each nonregistering battery to the registration point. The azimuth of each battery's orienting line minus the determined direction of fire equals the orienting angle for laying the battery.

Section II.

USE OF THE M10/M17 PLOTTING BOARD

14-11. DETERMINATION OF MAP DATA

There may be situations when use of the emergency chart procedures discussed so far may not be possible. In these cases, the XO may have to compute firing data himself by using the M10/M17 plotting board.

- a. The observer transmits the call for fire to the fire direction center. He transmits

target locations by use of any of the accepted methods of target location. However, the request MARK CENTER OF SECTOR should be avoided unless maps are unavailable.

b. Upon receipt of the call for fire, the XO must determine the direction and range to the target. He can do this by use of one of the following methods:

- (1) Given a MARK CENTER OF SECTOR call for fire or no map, he can use

his knowledge of the tactical situation to estimate an initial range and direction (azimuth) to the target.

(2) He can estimate the range and direction to the target from a map, if available.

(3) He can measure the range and direction from a map by using a range-deflection protractor.

14-12. CONVERSION OF MAP DATA INTO FIRE COMMANDS

Several steps are involved in the conversion of map data into initial fire commands when the M10/M17 plotting board must be used.

a. Determine the initial deflection to fire by comparing the azimuth to the initial target location with the azimuth of lay. Then, using the LARS rule, apply the difference to the common deflection of 3200. In mark center of sector missions and situations when the XO must estimate initial azimuth to the target, the initial deflection fired will normally be the deflection corresponding to the azimuth of lay; for example, deflection 3200. This will not be the case when the XO can measure a more accurate azimuth from his map.

b. Ignore site unless a large VI is indicated.

c. Determine elevation by using the range to the target obtained from the appropriate tabular firing table or graphical firing table.

d. Announce the initial fire commands in the usual manner.

e. Compute angle T by comparing the OT direction from the observer's call for fire and the azimuth from the battery to the target (GT direction). Throughout the mission, retain the angle T determined initially unless the weapons are shifted more than 200 mils from the deflection used to fire the initial round.

f. Determine 100/R at the initial range and record. It will be used in the computation of subsequent deflection shifts.

14-13. DETERMINATION OF DATA FOR SUBSEQUENT ROUNDS

a. Prepare the M10/M17 plotting board for observer's subsequent corrections by placing a mark on the *clear plastic disk* at the number on the outer black scale that corresponds to the OT direction and another mark opposite the GT direction. Label these marks O and G respectively so that by rotating the disk until one of the marks is opposite the head of the arrow (red zero) on the base of the plotting board, you can obtain a graphical representation of each subsequent correction in relation to either the OT line or the GT line.

b. The observer follows normal procedures during the adjustment. Thus, his subsequent corrections can be plotted on the M10/M17 plotting board and converted into corrections in relation to the GT line by remembering that *the center of the plotting board always represents the location of the last burst.*

(1) Using the procedures in *b* and *c* above, select an appropriate scale; that is, assign a convenient value to the squares on the plotting board. Most shifts can be plotted when a value of 10 or 20 meters is assigned to each small square. Use the 10-meters-per-square scale whenever possible, because it is easier to use and is more accurate.

(2) Rotate the disk until the mark representing the OT direction is over the red arrow on the base. The plotting board is now in OT position; that is, oriented in the OT direction.

(3) Remembering that the center of the plotting board represents the impact of the last round fired, plot the observer's correction on the disk.

(4) Rotate the disk until the G mark is over the red arrow. The plotting board is now in the GT position, or oriented along the GT direction (GT line).

(5) Starting from the center of the plotting board, measure the observer's correction in relation to the GT line as now represented by the red index arrow on the

base. Note that the observer's shift in relation to the OT line remains unchanged.

c. Firing data for subsequent rounds can now be determined as follows:

(1) **Deflection.** Determine deflection to fire the next round in an adjust fire mission. Convert the deviation correction (in meters) in relation to the GT line to a correction in mils. Apply the mil correction to the previous deflection fired as follows:

(a) Multiply the value of $100/R$ for the range to the target by the meter deviation, and divide the product by 100.

EXAMPLE:

$$\frac{100/R \times \text{meters deviation}}{100} = \text{deviation}$$

$100/R$ can be determined by the following formula:

$$\frac{100}{\text{Initially determined range (in thousands)}}$$

(b) To produce the deflection to fire, apply the correction, in mils, to the last deflection sent to the guns.

(2) **Elevation.** Both the GFT and the TFT can be used to determine elevation as follows:

(a) Using the GFT, first determine the range to fire the next round by adding/

subtracting the observer's range correction *along the GT line to the last range fired*. Then move the MHL over the new range. If there is a current GFT setting, read the elevation to fire the next round under the elevation gage line. If there is no current GFT setting, read the elevation to fire the next round under the manufacturer's hairline.

(b) Using the TFT, apply the following steps:

- Determine the C-factor (change in elevation for a 100-meter change in range) at the initial chart range by subtracting the elevation corresponding to the initial chart range from the elevation corresponding to a range 100 meters greater than the initial range. Express the amount to the nearest mil. This value is the C-factor that will be used throughout the mission.

- Compute the change in elevation required for the observer's range correction along the GT line by multiplying the C-factor by the change in range in hundreds.

$$\frac{\text{C-factor} \times \text{range correction}}{100} = \text{change in elevation}$$

- Apply the change in elevation to the last fired elevation. The result is the new elevation to fire.

Section III.

MAP-SPOT/SURVEYED FIRING CHART

14-14. DETERMINATION OF SURVEYED LOCATION AND AZIMUTH OF LAY

a. The surveyed location and azimuth of lay should be established as soon as possible. Surveyed locations are determined by the following:

(1) **Map spot.** Map spot is *fast*, but it is *less accurate*.

(2) **Survey.** Survey is *more accurate*, but it is *slower*.

b. If survey teams cannot provide the necessary data immediately, a map-spot survey is conducted by the battery to establish the battery center and azimuth of lay. To accomplish map-spot survey, associate terrain features with their locations on the map, and locate the battery center in relation to the terrain features. Use hasty survey methods.

14-15. MAP-SPOT TECHNIQUE

a. Map-Spot Survey. A map-spot survey is the application of basic map and terrain association. *Be as accurate as possible.* The preferred technique for establishing the battery center by map-spot survey is three-point resection. The map-spotted location of the battery center will include *eight-place grid coordinates and altitude (in meters).*

b. Directional Control. Directional control must also be provided; that is, an orienting station (OS) and the direction to the end of the orienting line (EOL). Common directional control should be established as soon as possible, preferably by simultaneous observation or directional traverse during the day, or the Polaris-Kochab method at night. If none of these procedures can be accomplished quickly, the battery must be laid magnetically. FM 6-50 contains a more detailed discussion of the techniques mentioned here.

14-16. CONSTRUCTION OF A MAP-SPOT SURVEYED FIRING CHART (MANUAL)

a. The FDC must be provided three items of information to construct a map-spot surveyed firing chart.

(1) Assumed grid coordinates of the battery center.

(2) Assumed altitude of the battery.

(3) Assumed azimuth of lay.

b. When the above information is received, the FDC constructs the firing chart.

c. When met + VE techniques cannot be used, the battery will register by firing as the situation permits.

d. A map-spot surveyed firing chart is only as accurate as—

(1) The map-spotted location of the battery center and the registration point.

(2) The azimuth of lay.

(3) The construction of the chart.

e. When using a map-spot surveyed firing chart, the orienting angle must be measured and recorded after the battery is laid. This will facilitate determining the actual azimuth of lay when directional control is provided.

f. Replot any fired targets.

g. If the FDO suspects an error in either the map-spotted location of the battery or the registration point, or both, the GFT setting is most likely incorrect if a registration has been conducted. The GFT setting should be discarded until better information is available.

14-17. TRANSFER FROM MAP-SPOT TO SURVEYED FIRING CHART

a. When the position and target area surveys are completed, the following information is provided to the fire direction center:

(1) Battery center—coordinates and altitude to the nearest 0.1 meter and azimuth to the EOL to the nearest 0.1 mil.

(2) Registration point—coordinates and altitude to the nearest 0.1 meter.

b. The surveyed firing chart is constructed to reflect the accurate locations of the battery center and the registration point and the actual azimuth of lay.

c. When the battery was initially laid, the orienting angle was measured and recorded. When the surveyed azimuth to the EOL is determined, the actual azimuth of lay must be computed by use of the following formula:

Azimuth to EOL - orienting angle =
azimuth of lay

The initial (map-spot) azimuth of lay may be in error. The actual azimuth on which the battery was laid before survey was most likely not the azimuth obtained after the battery was relaid on survey data.

d. When survey data are provided, the FDC must—

(1) Construct a surveyed firing chart.

(2) Recompute GFT settings.

HASTY SPECIAL CORRECTION TABLES

M110A1/2 203-MM (8-INCH) FT R-Q-1 M106		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S)									
		(METERS)										(METERS)																			
		RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200								
		MILS										MILS										MILS									
1000	3GB	20	40	60	80	100	120	140	160	180	200	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+1 -2	+1 -2
1500	3GB	13	26	40	53	66	80	93	106	120	133	1	1	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+1 -1	+1 -2	+1 -2	+2 -2	+2 -2	+2 -3	+2 -3
2000	4GB	10	20	30	40	50	60	70	80	90	100	0	1	2	3	4	4	5	6	7	8	+0 -1	+0 -1	+0 -1	+0 -1	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+1 -2
2500	4GB	8	16	24	32	40	48	56	64	72	80	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3
3000	4GB	6	13	20	26	33	40	46	53	60	66	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3	+3 -4
3500	4GB	5	11	17	22	28	34	40	45	51	57	1	2	3	4	6	7	8	9	10	12	+0 -0	+0 -0	+0 -0	+1 -1	+1 -1	+1 -1	+2 -2	+2 -2	+2 -2	+3 -3
4000	4GB	5	10	15	20	25	30	35	40	45	50	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3	+3 -4	+3 -4
4500	4GB	4	8	13	17	22	26	31	35	40	44	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+3 -4
5000	5GB	4	8	12	16	20	24	28	32	36	40	0	1	2	3	4	4	5	6	7	8	+0 -0	+0 -0	+0 -0	+1 -1	+1 -1	+1 -1	+2 -2	+2 -2	+2 -2	+3 -3
5500	5GB	3	7	10	14	18	21	25	29	32	36	1	2	3	4	6	7	8	9	10	12	+0 -0	+1 -1	+1 -1	+2 -2	+2 -2	+3 -0	+3 -3	+4 -4	+4 -4	+5 -5
6000	5GB	3	6	10	13	16	20	23	26	30	33	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6
6500	5GB	3	6	9	12	15	18	21	24	27	30	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6
7000	5GB	2	5	8	11	14	17	20	22	25	28	1	2	3	4	6	7	8	9	10	12	+0 -0	+1 -1	+1 -1	+2 -2	+2 -2	+3 -3	+3 -3	+4 -4	+5 -5	+5 -5
7500	5GB	2	5	8	10	13	16	18	21	24	26	1	2	3	4	6	7	8	9	10	12	+0 -0	+1 -1	+1 -1	+2 -2	+2 -2	+3 -3	+4 -4	+4 -4	+5 -5	+5 -5
8000	5GB	2	5	7	10	12	15	17	20	22	25	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7

Appendix A

M110A1/2 203-MM (8-INCH) FT R-Q-1 M106		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B) (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S) -5 -1.0 -1.5 -2.0 -2.5 -3.0 -3.5 -4.0 -4.5 -5.0 +5 +1.0 +1.5 +2.0 +2.5 +3.0 +3.5 +4.0 +4.5 +5.0									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200										
		MILS										MILS										MILS									
8500	5GB	2	4	7	9	11	14	16	18	21	23	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7
9000	5GB	2	4	6	8	11	13	15	17	20	22	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+6 -7	+7 -8	+8 -9
9500	5GB	2	4	6	8	10	12	14	16	18	21	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+8 -9
10000	5GB	2	4	6	8	10	12	14	16	18	20	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10
10500	5GB	1	3	5	7	9	11	13	15	17	19	2	4	6	8	10	12	14	16	18	20	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -12
11000	7WB	1	3	5	7	9	10	12	14	16	18	0	1	2	3	4	4	5	6	7	8	+0 -1	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5
11500	7WB	1	3	5	6	8	10	12	13	15	17	0	1	2	3	4	4	5	6	7	8	+0 -1	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5
12000	7WB	1	3	5	6	8	10	11	13	15	16	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+5 -6	+5 -6	+6 -7	+7 -8
12500	7WB	1	3	4	6	8	9	11	12	14	16	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+5 -6	+5 -6	+6 -7	+7 -8
13000	7WB	1	3	4	6	7	9	10	12	13	15	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+6 -7	+6 -7	+7 -8
13500	7WB	1	2	4	5	7	8	10	11	13	14	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+6 -7	+6 -7	+7 -8
14000	7WB	1	2	4	5	7	8	10	11	12	14	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+6 -7	+6 -7	+7 -8
14500	7WB	1	2	4	5	6	8	9	11	12	13	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+7 -8
15000	7WB	1	2	4	5	6	8	9	10	12	13	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11
15500	7WB	1	2	3	5	6	7	9	10	11	12	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11

M110A1/2 203-MM (8-INCH) FT R-Q-1 M106		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B) (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S) -5 -1.0 -1.5 -2.0 -2.5 -3.0 -3.5 -4.0 -4.5 -5.0 +5 +1.0 +1.5 +2.0 +2.5 +3.0 +3.5 +4.0 +4.5 +5.0									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200	MILS									
16000	7WB	1	2	3	5	6	7	8	10	11	12	2	4	6	8	10	12	14	16	18	20	+1	+2	+4	+5	+7	+8	+9	+11	+12	+14
16500	8WB	1	2	3	4	6	7	8	9	10	12	1	2	3	4	6	7	8	9	10	12	+0	+1	+2	+3	+4	+5	+6	+7	+8	
17000	8WB	1	2	3	4	5	7	8	9	10	11	1	2	3	4	6	7	8	9	10	12	+0	+1	+2	+3	+4	+4	+5	+6	+7	+8
17500	8WB	1	2	3	4	5	6	8	9	10	11	1	2	3	4	6	7	8	9	10	12	+0	+1	+2	+3	+4	+5	+5	+6	+7	+8
18000	8WB	1	2	3	4	5	6	7	8	10	11	1	2	3	4	6	7	8	9	10	12	+0	+1	+2	+3	+4	+5	+6	+6	+7	+8
18500	8WB	1	2	3	4	5	6	7	8	9	10	1	3	4	6	8	9	11	12	14	16	+1	+2	+3	+4	+5	+6	+8	+9	+10	+11
19000	8WB	1	2	3	4	5	6	7	8	9	10	1	3	4	6	8	9	11	12	14	16	+1	+2	+3	+4	+5	+6	+8	+9	+10	+11
19500	8WB	1	2	3	4	5	6	7	8	9	10	2	4	6	8	10	12	14	16	18	20	+1	+2	+4	+5	+7	+8	+10	+11	+13	+14
20000	9	1	2	3	4	5	6	7	8	9	10	1	2	3	4	6	7	8	9	10	12	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
20500	9	0	1	2	3	4	5	6	7	8	9	1	2	3	4	6	7	8	9	10	12	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
21000	9	0	1	2	3	4	5	6	7	8	9	1	2	3	4	6	7	8	9	10	12	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
21500	9	0	1	2	3	4	5	6	7	8	9	1	3	4	6	8	9	11	12	14	16	+1	+2	+3	+5	+6	+7	+8	+10	+11	+12
22000	9	0	1	2	3	4	5	6	7	8	9	2	4	6	8	10	12	14	16	18	20	+1	+3	+4	+6	+8	+9	+11	+13	+14	+16

M110A2 FT 8-S-1 M650		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B) (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S) -5 -1.0 -1.5 -2.0 -2.5 -3.0 -3.5 -4.0 -4.5 -5.0 +5 +1.0 +1.5 +2.0 +2.5 +3.0 +3.5 +4.0 +4.5 +5.0									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200										
		MILS										MILS										MILS									
2000	4GB	10	20	30	40	50	60	70	80	90	100	0	1	2	3	4	4	5	6	7	8	+0	+0	+0	+0	+0	+0	+0	+1	+1	+1
2500	4GB	8	16	24	32	40	48	56	64	72	80	1	2	3	4	6	7	8	9	10	12	+0	+0	+0	+0	+1	+1	+1	+1	+1	+2
3000	4GB	6	13	20	26	33	40	46	53	60	66	1	2	3	4	6	7	8	9	10	12	+0	+0	+0	+0	+1	+1	+1	+1	+2	+2
3500	4GB	5	11	17	22	28	34	40	45	51	57	1	2	3	4	6	7	8	9	10	12	+0	+0	+0	+1	+1	+1	+1	+2	+2	+2
4000	4GB	5	10	15	20	25	30	35	40	45	50	1	2	3	4	6	7	8	9	10	12	+0	+0	+0	+1	+1	+1	+1	+2	+2	+2
4500	4GB	4	8	13	17	22	26	31	35	40	44	1	2	3	4	6	7	8	9	10	12	+0	+0	+0	+1	+1	+1	+2	+2	+2	+3
5000	4GB	4	8	12	16	20	24	28	32	36	40	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+1	+2	+2	+2	+3	+3
5500	4GB	3	7	10	14	18	21	25	29	32	36	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+1	+2	+2	+3	+3	+3
6000	5GB	3	6	10	13	16	20	23	26	30	33	1	2	3	4	6	7	8	9	10	12	+0	+1	+1	+2	+2	+3	+3	+4	+4	+5
6500	5GB	3	6	9	12	15	18	21	24	27	30	1	2	3	4	6	7	8	9	10	12	+0	+1	+1	+2	+2	+3	+3	+4	+5	+5
7000	5GB	2	5	8	11	14	17	20	22	25	28	1	2	3	4	6	7	8	9	10	12	+0	+1	+1	+2	+2	+3	+4	+4	+5	+5
7500	5GB	2	5	8	10	13	16	18	21	24	26	1	2	3	4	6	7	8	9	10	12	+0	+1	+1	+2	+3	+3	+4	+4	+5	+6
8000	5GB	2	5	7	10	12	15	17	20	22	25	1	2	3	4	6	7	8	9	10	12	+0	+1	+1	+2	+3	+3	+4	+5	+5	+6
8500	5GB	2	4	7	9	11	14	16	18	21	23	1	2	3	4	6	7	8	9	10	12	+0	+1	+1	+2	+3	+3	+4	+5	+5	+6
9000	5GB	2	4	6	8	11	13	15	17	20	22	1	3	4	6	8	9	11	12	14	16	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
																						-1	-2	-3	-4	-5	-6	-7	-8	-9	-9

M110A2 FT 8-S-1 M650		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R)											HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B)											HASTY MUZZLE VELOCITY CORRECTIONS (M/S)										
		(METERS)											(METERS)											-5 -1.0 -1.5 -2.0 -2.5 -3.0 -3.5 -4.0 -4.5 -5.0 +5 +1.0 +1.5 +2.0 +2.5 +3.0 +3.5 +4.0 +4.5 +5.0										
		RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200											
		MILS											MILS											MILS										
9500	5GB	2	4	6	8	10	12	14	16	18	21	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10			
10000	5GB	2	4	6	8	10	12	14	16	18	20	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10			
10500	5GB	1	3	5	7	9	11	13	15	17	19	2	4	6	8	10	12	14	16	18	20	+1 -2	+2 -3	+3 -4	+5 -5	+6 -7	+7 -8	+8 -9	+10 -10	+11 -11	+12 -12			
11000	6WB	1	3	5	7	9	10	12	14	16	18	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+7 -8			
11500	6WB	1	3	5	6	8	10	12	13	15	17	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+7 -8			
12000	6WB	1	3	5	6	8	10	11	13	15	16	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+5 -6	+6 -7	+7 -8	+7 -8			
12500	6WB	1	3	4	6	8	9	11	12	14	16	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+10 -10	+11 -11			
13000	6WB	1	3	4	6	7	9	10	12	13	15	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+8 -8	+9 -10	+10 -11	+11 -12			
13500	6WB	1	2	4	5	7	8	10	11	13	14	2	4	6	8	10	12	14	16	18	20	+1 -2	+2 -3	+4 -5	+5 -6	+7 -8	+8 -9	+10 -11	+11 -12	+13 -13	+14 -15			
14000	8	1	2	4	5	7	8	10	11	12	14	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+5 -5	+5 -6			
14500	8	1	2	4	5	6	8	9	11	12	13	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+5 -6			
15000	8	1	2	4	5	6	8	9	10	12	13	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+5 -6			
15500	8	1	2	3	5	6	7	9	10	11	12	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+5 -6			
16000	8	1	2	3	5	6	7	8	10	11	12	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6	+6 -6			
16500	8	1	2	3	4	6	7	8	9	10	12	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7			

M110A2 FT 8-S-1 M650		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S)											
		(METERS)										(METERS)										-5 -1.0 -1.5 -2.0 -2.5 -3.0 -3.5 -4.0 -4.5 -5.0 +5 +1.0 +1.5 +2.0 +2.5 +3.0 +3.5 +4.0 +4.5 +5.0											
		RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200										
		MILS										MILS										MILS											
17000	8	1	2	3	4	5	7	8	9	10	11	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7		
17500	8	1	2	3	4	5	6	8	9	10	11	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10		
18000	8	1	2	3	4	5	6	7	8	10	11	1	2	3	4	6	7	8	9	10	12	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10		
18500	8	1	2	3	4	5	6	7	8	9	10	1	2	3	4	6	7	8	9	10	12	+0 -2	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10		
19000	8	1	2	3	4	5	6	7	8	9	10	1	2	3	4	6	7	8	9	10	12	+0 -0	+1 -1	+2 -2	+3 -3	+4 -4	+5 -5	+6 -6	+7 -7	+8 -8	+9 -9		
19500	8	1	2	3	4	5	6	7	8	9	10	1	2	3	4	6	7	8	9	10	12	+0 -2	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10		
20000	8	1	2	3	4	5	6	7	8	9	10	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+4 -4	+5 -6	+6 -7	+8 -8	+9 -10	+10 -11	+12 -12	+13 -14		
20500	8	0	1	2	3	4	5	6	7	8	9	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+4 -5	+5 -6	+6 -7	+8 -8	+9 -10	+10 -11	+12 -12	+13 -14		
21000	9	0	1	2	3	4	5	6	7	8	9	1	2	3	4	6	7	8	9	10	12	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11		
21500	9	0	1	2	3	4	5	6	7	8	9	1	2	3	4	6	7	8	9	10	12	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11		
22000	9	0	1	2	3	4	5	6	7	8	9	1	2	3	4	6	7	8	9	10	12	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11		
22500	9	0	1	2	3	4	5	6	7	8	8	1	3	4	6	8	9	11	12	14	16	+1 -1	+2 -2	+4 -4	+5 -5	+7 -7	+8 -8	+10 -10	+11 -11	+12 -12	+14 -14		
23000	9	0	1	2	3	4	5	6	6	7	8	1	3	4	6	8	9	11	12	14	16	+1 -2	+2 -3	+4 -5	+5 -6	+7 -8	+8 -9	+10 -11	+11 -12	+12 -14	+14 -15		
23500	9	0	1	2	3	4	5	5	6	7	8	2	4	6	8	10	12	14	16	18	20	+1 -1	+3 -3	+5 -5	+7 -7	+9 -9	+10 -11	+12 -12	+14 -14	+16 -16	+18 -18		
24000	8R	0	1	2	3	4	5	5	6	7	8	1	2	3	4	6	7	8	9	10	12	+1 -2	+2 -3	+3 -4	+4 -5	+6 -7	+7 -8	+8 -9	+9 -10	+11 -11	+12 -13		

M110A2 FT 8-S-1 M650		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R) (METERS)											HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B) (METERS)											HASTY MUZZLE VELOCITY CORRECTIONS (M/S)											
																								-5 -1.0 -1.5 -2.0 -2.5 -3.0 -3.5 -4.0 -4.5 -5.0 +5 +1.0 +1.5 +2.0 +2.5 +3.0 +3.5 +4.0 +4.5 +5.0											
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200														
		MILS											MILS											MILS											
24500	8R	0	1	2	3	4	4	5	6	7	8	1	3	4	6	8	9	11	12	14	16	+1 -1	+3 -3	+4 -4	+6 -6	+8 -8	+9 -9	+11 -11	+13 -13	+14 -14	+16 -16				
25000	8R	0	1	2	3	4	4	5	6	7	8	1	3	4	6	8	9	11	12	14	16	+1 -2	+3 -4	+5 -6	+6 -7	+8 -9	+10 -11	+11 -12	+13 -14	+15 -16	+16 -17				
25500	8R	0	1	2	3	3	4	5	6	7	7	2	4	6	8	10	12	14	16	18	20	+2 -3	+4 -5	+6 -7	+8 -9	+10 -11	+12 -13	+14 -15	+16 -17	+19 -20	+21 -22				
26000	9R	0	1	2	3	3	4	5	6	6	7	0	1	2	3	4	4	5	6	7	8	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -6	+7 -7	+7 -8	+8 -9				
26500	9R	0	1	2	3	3	4	5	6	6	7	1	2	3	4	6	7	8	9	10	12	+1 -2	+2 -3	+4 -4	+5 -6	+6 -7	+8 -8	+9 -10	+10 -11	+12 -12	+13 -14				
27000	9R	0	1	2	2	3	4	5	5	6	7	1	2	3	4	6	7	8	9	10	12	+1 -2	+2 -3	+4 -5	+5 -6	+7 -7	+8 -9	+9 -10	+11 -11	+12 -13	+14 -14				
27500	9R	0	1	2	2	3	4	5	5	6	7	1	2	3	4	6	7	8	9	10	12	+1 -2	+2 -3	+4 -5	+5 -6	+7 -8	+8 -9	+10 -10	+11 -12	+13 -13	+14 -14				
28000	9R	0	1	2	2	3	4	5	5	6	7	1	2	3	4	6	7	8	9	10	12	+1 -2	+3 -3	+4 -5	+6 -6	+7 -8	+9 -9	+11 -11	+12 -12	+14 -14	+15 -15				
28500	9R	0	1	2	2	3	4	4	5	6	7	1	3	4	6	8	9	11	12	14	16	+2 -3	+4 -5	+6 -7	+9 -9	+11 -11	+13 -13	+16 -15	+18 -17	+20 -19	+23 -21				
29000	9R	0	1	2	2	3	4	4	5	6	6	2	4	6	8	10	12	14	16	18	20	+3 -3	+6 -6	+9 -9	+12 -12	+15 -14	+18 -17	+21 -20	+24 -23	+27 -26	+30 -28				

M109A2/3 M198 155-AN-1 483A1		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B) (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S)									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200										
		MILS										MILS										MILS									
1000	4GB	20	40	60	80	100	120	140	160	180	200	1	2	3	4	6	7	8	9	10	12	+0	+0	+0	+0	+0	+1	+1	+1	+1	+1
1500	4GB	13	26	40	53	66	80	93	106	120	133	1	2	3	4	6	7	8	9	10	12	+0	+0	+0	+0	+0	+1	+1	+1	+1	+1
2000	4GB	10	20	30	40	50	60	70	80	90	100	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+1	+2	+2	+2	+3	+3
2500	4GB	8	16	24	32	40	48	56	64	72	80	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+2	+2	+3	+3	+4	+4
3000	5GB	6	13	20	26	33	40	46	53	60	66	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+1	+2	+2	+2	+3	+3
3500	5GB	5	11	17	2	28	34	40	45	51	57	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+1	+2	+2	+3	+3	+3
4000	5GB	5	10	15	20	25	30	35	40	45	50	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+2	+2	+2	+3	+3	+3
4500	5GB	4	8	13	17	22	26	31	35	40	44	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+2	+2	+3	+3	+4	+4
5000	5GB	4	8	12	16	20	24	28	32	36	40	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+2	+2	+3	+3	+4	+4
5500	5GB	3	7	10	14	18	21	25	29	32	36	1	2	3	4	6	7	8	9	10	12	+0	+1	+1	+2	+2	+3	+3	+4	+4	+5
6000	5GB	3	6	10	13	16	20	23	26	30	33	1	3	4	6	8	9	11	12	14	16	+0	+1	+2	+3	+3	+4	+5	+6	+6	+7
6500	5GB	3	6	9	12	15	18	21	24	27	30	1	3	4	6	8	9	11	12	14	16	+0	+1	+2	+3	+4	+4	+5	+6	+7	+8
7000	5GB	2	5	8	11	14	17	20	22	25	28	1	3	4	6	8	9	11	12	14	16	+0	+1	+2	+3	+4	+5	+6	+6	+7	+8
7500	7WB	2	5	8	10	13	16	18	21	24	26	0	1	2	3	4	4	5	6	7	8	+0	+0	+1	+1	+1	+2	+2	+3	+3	+3
8000	7WB	2	5	7	19	12	15	17	20	22	25	0	1	2	3	4	4	5	6	7	8	+0	+0	+1	+1	+2	+2	+2	+3	+3	+4

M109A2/3 M198 155-AM-1 483A1		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B) (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S) -5 -1.0 -1.5 -2.0 -2.5 -3.0 -3.5 -4.0 -4.5 -5.0 +5 +1.0 +1.5 +2.0 +2.5 +3.0 +3.5 +4.0 +4.5 +5.0									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200	MILS									
8500	7WB	2	4	7	9	11	14	16	18	21	23	0	1	2	3	4	4	5	6	7	8	+0	+0	+1	+1	+2	+2	+2	+3	+3	+4
9000	7WB	2	4	6	8	11	13	15	17	20	22	0	1	2	3	4	4	5	6	7	8	+0	+0	+1	+1	+2	+2	+2	+3	+3	+4
9500	7WB	2	4	6	8	10	12	14	16	18	21	1	2	3	4	6	7	8	9	10	12	+0	+1	+1	+2	+3	+3	+4	+5	+5	+6
10000	7WB	2	4	6	8	10	12	14	16	18	20	1	2	3	4	6	7	8	9	10	12	+0	+1	+1	+2	+3	+4	+4	+5	+6	+6
10500	7WB	1	3	5	7	9	11	13	15	17	19	1	2	3	4	6	7	8	9	10	12	+0	+1	+2	+2	+3	+4	+4	+5	+6	+6
11000	7WB	1	3	5	7	9	10	12	14	16	18	1	2	3	4	6	7	8	9	10	12	+0	+1	+2	+2	+3	+4	+4	+5	+6	+6
11500	7WB	1	3	5	6	8	10	12	13	15	17	1	2	3	4	6	7	8	9	10	12	+1	+1	+2	+3	+4	+4	+5	+6	+6	+7
12000	7WB	1	3	5	6	8	10	11	13	15	16	1	3	4	6	8	9	11	12	14	16	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
12500	7WB	1	3	4	6	8	9	11	12	14	16	1	3	4	6	8	9	11	12	14	16	+0	+2	+2	+4	+4	+6	+6	+8	+8	+10
13000	7WB	1	3	4	6	7	9	10	12	13	15	2	4	6	8	10	12	14	16	18	20	+1	+2	+3	+5	+6	+7	+9	+10	+11	+12
13500	7WB	1	2	4	5	7	8	10	11	13	14	2	5	7	10	12	14	17	19	22	24	+1	+3	+4	+6	+7	+9	+11	+12	+14	+15
14000	7WB	1	2	4	5	7	8	10	11	12	14	4	7	11	14	18	22	25	29	32	36	+2	+5	+7	+10	+12	+15	+17	+20	+22	+25
14500	8WB	1	2	4	5	6	8	9	11	12	13	1	2	3	4	6	7	8	9	10	12	+0	+1	+2	+3	+3	+4	+5	+6	+6	+7
15000	8WB	1	2	4	5	6	8	9	10	12	13	1	3	4	6	8	9	11	12	14	16	+0	+2	+3	+4	+5	+6	+7	+8	+9	+10
15500	8WB	1	2	3	5	6	7	9	10	11	12	1	3	4	6	8	9	11	12	14	16	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10
16000	8WB	1	2	3	5	6	7	8	10	11	12	1	3	4	6	8	9	11	12	14	16	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10
16500	8WB	1	2	3	4	6	7	8	9	10	12	2	4	6	8	10	12	14	16	18	20	+1	+2	+4	+5	+6	+8	+9	+11	+12	+13

M109A2/3 M198 155-AM-1 483A1		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B) (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S) -5 -1.0 -1.5 -2.0 -2.5 -3.0 -3.5 -4.0 -4.5 -5.0 +5 +1.0 +1.5 +2.0 +2.5 +3.0 +3.5 +4.0 +4.5 +5.0									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200										
		MILS										MILS										MILS									
17000	8WB	1	2	3	4	5	7	8	9	10	11	3	6	10	13	16	19	22	26	29	32	+2	+5	+7	+9	+12	+14	+16	+18	+20	+23
																						-2	-4	-7	-9	-11	-13	-15	-18	-20	-22

M109A2/3 M198 155-AM-2 M107		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (METERS) (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S) -5 -1.0 -1.5 -2.0 -2.5 -3.0 -3.5 -4.0 -4.5 -5.0 +5 +1.0 +1.5 +2.0 +2.5 +3.0 +3.5 +4.0 +4.5 +5.0									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200										
		MILS										MILS										MILS									
1000	4GB	20	40	60	80	100	120	140	160	180	200	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+1	+1	+1	+1	+2	+2
1500	4GB	13	26	40	53	66	80	93	106	120	133	1	2	3	4	6	7	8	9	10	12	-0	-0	-0	-1	-1	-1	-1	-1	-1	-2
2000	4GB	10	20	30	40	50	60	70	80	90	100	1	2	3	4	6	7	8	9	10	12	+0	+0	+0	+1	+1	+1	+1	+2	+2	+2
2500	4GB	8	16	24	32	40	48	56	64	72	80	1	2	3	4	6	7	8	9	10	12	-1	-1	-1	-1	-2	-2	-2	-2	-3	-3
3000	4GB	6	13	20	26	33	40	46	53	60	66	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+2	+2	+3	+3	+3	+4
3500	4GB	5	11	17	22	28	34	40	45	51	57	1	2	3	4	6	7	8	9	10	12	-1	-1	-2	-2	-2	-3	-3	-4	-4	-4
4000	5GB	5	10	15	20	25	30	35	40	45	50	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+1	+2	+2	+2	+3	+3
4500	5GB	4	8	13	17	22	26	31	35	40	44	1	2	3	4	6	7	8	9	10	12	-1	-1	-2	-2	-2	-3	-3	-4	-4	-4
5000	5GB	4	8	12	16	20	24	28	32	36	40	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+1	+2	+2	+3	+3	+3
5500	5GB	3	7	10	14	18	21	25	29	32	36	1	2	3	4	6	7	8	9	10	12	-0	-0	-1	-1	-2	-2	-2	-3	-3	-4
6000	5GB	3	6	10	13	16	20	23	26	30	33	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+2	+2	+3	+3	+4	+4
6500	5GB	3	6	9	12	15	18	21	24	27	30	1	3	4	6	8	9	11	12	14	16	-1	-2	-2	-2	-3	-3	-4	-4	-5	-5

M109A2/3 M198 155-AM-2 M107		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (F/B) (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S) -5 -1.0 -1.5 -2.0 -2.5 -3.0 -3.5 -4.0 -4.5 -5.0 +5 +1.0 +1.5 +2.0 +2.5 +3.0 +3.5 +4.0 +4.5 +5.0									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200										
		MILS										MILS										MILS									
7000	5GB	2	5	8	11	14	17	20	22	25	28	1	3	4	6	8	9	11	12	14	16	+0	+1	+2	+2	+3	+4	+4	+5	+6	+6
7500	5GB	2	5	8	10	13	16	18	21	24	26	1	3	4	6	8	9	11	12	14	16	+0	+1	+2	+2	+3	+4	+5	+5	+6	+7
8000	5GB	2	5	7	10	12	15	17	20	22	25	2	4	6	8	10	12	14	16	18	20	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
8500	6WB	2	4	7	9	11	14	16	18	21	23	1	2	3	4	6	7	8	9	10	12	+0	+1	+1	+2	+2	+3	+4	+4	+5	+5
9000	6WB	2	4	6	8	11	13	15	17	20	22	1	2	3	4	6	7	8	9	10	12	+0	+1	+1	+2	+3	+3	+4	+4	+5	+6
9500	6WB	2	4	6	8	10	12	14	16	18	21	1	3	4	6	8	9	11	12	14	16	+0	+1	+2	+3	+4	+5	+5	+6	+7	+8
10000	6WB	2	4	6	8	10	12	14	16	18	20	1	3	4	6	8	9	11	12	14	16	+0	+1	+2	+3	+4	+5	+6	+6	+7	+8
10500	6WB	1	3	5	7	9	11	13	15	17	19	1	3	4	6	8	9	11	12	14	16	+0	+1	+2	+3	+4	+5	+6	+7	+8	+8
11000	6WB	1	3	5	7	9	10	12	14	16	18	2	4	6	8	10	12	14	16	18	20	+1	+2	+3	+4	+5	+6	+8	+9	+10	+11
11500	7WB	1	3	5	6	8	10	12	13	15	17	1	2	3	4	6	7	8	9	10	12	+0	+1	+1	+2	+3	+4	+4	+5	+6	+6
12000	7WB	1	3	5	6	8	10	11	13	15	16	1	2	3	4	6	7	8	9	10	12	+0	+1	+2	+2	+3	+4	+4	+5	+6	+6
12500	7WB	1	3	4	6	8	9	11	12	14	16	1	3	4	6	8	9	11	12	14	16	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
13000	7WB	1	3	4	6	7	9	10	12	13	15	1	3	4	6	8	9	11	12	14	16	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
13500	7WB	1	2	4	5	7	8	10	11	13	14	2	4	6	8	10	12	14	16	18	20	+1	+2	+3	+4	+6	+7	+8	+9	+11	+12
14000	7WB	1	2	4	5	7	8	10	11	12	14	2	5	7	10	12	14	17	19	22	24	+2	+3	+5	+6	+8	+9	+11	+12	+14	+15
14500	8	1	2	4	5	6	8	9	11	12	13	1	2	3	4	6	7	8	9	10	12	+0	+1	+2	+2	+3	+4	+4	+5	+6	+7
15000	8	1	2	4	5	6	8	9	10	12	13	1	2	3	4	6	7	8	9	10	12	+0	+1	+2	+2	+3	+4	+5	+5	+6	+7

M109A2/3 M198 155-AM-2 M107		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S)									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200										
		MILS										MILS										MILS									
15500	8	1	2	3	5	6	7	9	10	11	12	1	2	3	4	6	7	8	9	10	12	+0	+1	+2	+2	+3	+4	+5	+5	+6	+7
																						-1	-2	-3	-3	-4	-5	-6	-6	-7	-8
16000	8	1	2	3	5	6	7	8	10	11	12	1	3	4	6	8	9	11	12	14	16	+0	+2	+2	+4	+5	+6	+7	+8	+9	+10
																						-2	-2	-4	-4	-5	-6	-7	-8	-9	-10
16500	8	1	2	3	4	6	7	8	9	10	12	1	3	4	6	8	9	11	12	14	16	+0	+2	+3	+4	+5	+6	+7	+8	+9	+10
																						-2	-3	-4	-5	-6	-7	-8	-9	-10	-11
17000	8	1	2	3	4	5	7	8	9	10	11	2	4	6	8	10	12	14	16	18	20	+1	+2	+3	+5	+6	+7	+9	+10	+11	+12
																						-2	-3	-4	-6	-7	-8	-10	-11	-12	-13
17500	8	1	2	3	4	5	6	8	9	10	11	3	6	8	11	14	17	20	22	25	28	+1	+3	+5	+7	+9	+11	+13	+15	+17	+19
																						-2	-4	-6	-8	-10	-12	-14	-15	-17	-19

M102 105-AS-2		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R) (METERS)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS (METERS)										HASTY MUZZLE VELOCITY CORRECTIONS (M/S)									
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200										
		MILS										MILS										MILS									
1000	5	20	40	60	80	100	120	140	160	180	200	1	2	3	4	6	7	8	9	10	12	+0	+0	+0	+0	+0	+0	+1	+1	+1	+1
																						-1	-1	-1	-1	-1	-1	-1	-2	-2	-2
1500	5	13	26	40	53	66	80	93	106	120	133	1	2	3	4	6	7	8	9	10	12	+0	+0	+0	+0	+1	+1	+1	+1	+2	+2
																						-1	-1	-1	-1	-1	-2	-2	-2	-2	-2
2000	5	10	20	30	40	50	60	70	80	90	100	1	2	3	4	6	7	8	9	10	12	+0	+0	+0	+1	+1	+1	+1	+2	+2	+2
																						-1	-1	-1	-1	-2	-2	-2	-3	-3	-3
2500	5	8	16	24	32	40	48	56	64	72	80	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+1	+2	+2	+2	+3	+3
																						-1	-1	-1	-2	-2	-2	-2	-3	-3	-3
3000	5	6	13	20	26	33	40	46	53	60	66	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+2	+2	+2	+3	+3	+3
																						-1	-1	-1	-2	-2	-2	-3	-3	-3	-4
3500	5	5	11	17	22	28	34	40	45	51	57	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+2	+2	+3	+3	+4	+4
																						-1	-1	-2	-2	-2	-3	-3	-3	-4	-4
4000	6	5	10	15	20	25	30	35	40	45	50	1	2	3	4	6	7	8	9	10	12	+0	+0	+1	+1	+1	+2	+2	+2	+3	+3
																						-0	-0	-1	-1	-1	-2	-2	-2	-3	-3

M102 105-AS-2		HASTY POSITION DEFLECTION CORRECTIONS LATERAL CORRECTION (L/R)										HASTY POSITION QUADRANT ELEVATION CORRECTIONS										HASTY MUZZLE VELOCITY CORRECTIONS (M/S)									
		(METERS)										(METERS)																			
RANGE	CHG	20	40	60	80	100	120	140	160	180	200	20	40	60	80	100	120	140	160	180	200										
		MILS										MILS										MILS									
4500	6	4	8	13	17	22	26	31	35	40	44	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3	+3 -4	+3 -4
5000	6	4	8	12	16	20	24	28	32	36	40	1	2	3	4	6	7	8	9	10	12	+0 -0	+0 -0	+1 -1	+1 -1	+1 -1	+2 -2	+2 -2	+3 -3	+3 -3	+3 -3
5500	6	3	7	10	14	18	21	25	29	32	36	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+1 -3	+2 -3	+2 -3	+3 -4	+3 -4	+3 -5
6000	6	3	6	10	13	16	20	23	26	27	33	1	2	3	4	6	7	8	9	10	12	+0 -1	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+2 -3	+3 -4	+3 -4	+4 -5
6500	6	3	6	9	12	15	18	21	24	25	30	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+5 -6
7000	6	2	5	8	11	14	17	20	22	24	28	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+4 -5	+5 -6	+6 -7
7500	6	2	5	8	10	13	16	18	21	22	26	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+1 -2	+2 -3	+3 -4	+3 -4	+4 -5	+5 -6	+5 -6	+6 -7
8000	6	2	5	7	10	12	15	17	20	21	25	2	4	6	8	10	12	14	16	18	20	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -5	+5 -6	+6 -7	+7 -8	+8 -9
8500	6	2	4	7	9	11	14	16	18	20	23	2	5	7	10	12	14	17	19	22	24	+0 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11
9000	7	2	4	6	8	11	13	15	17	18	22	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -2	+2 -3	+3 -4	+4 -4	+4 -5	+5 -6	+5 -6	+6 -7
9500	7	2	4	6	8	10	12	14	16	18	21	1	3	4	6	8	9	11	12	14	16	+0 -1	+1 -2	+2 -3	+2 -3	+3 -4	+4 -5	+4 -5	+5 -6	+5 -6	+6 -7
10000	7	2	4	5	8	10	12	14	16	17	20	2	4	6	8	10	12	14	16	18	20	+0 -1	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -7	+7 -8	+8 -9
10500	7	1	3	5	7	9	11	13	15	16	19	2	5	7	10	12	14	17	19	22	24	+1 -2	+2 -3	+3 -4	+4 -5	+5 -6	+6 -7	+7 -8	+8 -9	+9 -10	+10 -11
11000	7	1	3	5	7	9	10	12	14	15	18	3	6	10	13	16	19	22	26	29	32	+1 -2	+2 -4	+4 -5	+5 -6	+7 -8	+8 -9	+10 -11	+12 -12	+3 -14	+14 -15

APPENDIX B

INTERCHANGEABILITY OF AMMUNITION

Refer to FM 6-50 for information on the interchangeability of ammunition.

APPENDIX C FIRE DIRECTION CENTER EQUIPMENT

CONTENTS OF FIRE DIRECTION SETS, ARTILLERY

ITEM	NATIONAL STOCK NUMBER	QUANTITY
Fire direction set 3, artillery, 30,000 meters max range (LIN H55843); 19200, consisting of the following components:	1290-00-299-6892	1 set
Carrying case, field artillery fire direction center equipment: canvas, 50 inches long, 40 inches high, 8 inches thick, folded;	1290-00-694-5190	1 ea
Drawing board and trestle: 48 inches long, 36 inches wide, nonslope, folding trestle, 36 inches high;	6675-00-248-1244	1 ea
Plotting sheet: 1,000-meter grid, 47 inches long, 35 inches wide;	7530-00-656-0812	12 ea
Protractor, fan, range deflection, 30,000 meters range, 11834239 (19200).	1290-00-266-6891	1 ea
Fire direction set 4, artillery, 15,000 meters max range (LIN H55706), consisting of the following components:	1290-00-299-6893	1 set
Carrying case, field artillery fire direction center equipment: canvas, 45 inches long, 33 inches high, 8 inches thick, folded;	1290-00-694-5191	1 ea
Drawing board and trestle: 42 inches long, 31 inches wide;	6675-00-248-1243	1 ea
Plotting sheet: 1,000-meter grid, 41 1/2 inches long, 30 inches wide;	7530-00-656-0813	12 ea
Protractor, fan, range deflection, 25,000 meters range.	1290-00-266-6890	1 ea

CONTENTS OF PLOTTING SET, ARTILLERY FIRE CONTROL

ITEM	NATIONAL STOCK NUMBER	QUANTITY
Plotting set, artillery fire control (line item no P09818), consisting of the following components:	6675-00-641-3630	1 set

ITEM	NATIONAL STOCK NUMBER	QUANTITY
Chest, plotting equipment: command post, 81349 C-12044, D7242-1	6675-00-049-5132	1 ea
Map tack: metal, spherical head, 100 per box: FED spec FF-T-51, type 1		
Black, 0.25-inch head, steel pin, 0.50 inch long	7510-01-045-3527	2 boxes
Blue, 0.25-inch head, steel pin, 0.50 inch long	7510-01-046-5086	2 boxes
Green, 0.25-inch head, steel pin, 0.50 inch long	7510-01-045-3528	2 boxes
Red, 0.25-inch head, steel pin, 0.50 inch long	7510-01-045-3529	2 boxes
Black, 0.25-inch head, steel pin, 0.625 inch long	7510-01-046-5087	2 boxes
Pad, writing paper: ruled two sides, white, 10 1/2 inches long, 8 inches wide, 100 sheets per pad, 12 pads per package, 81348 UU-P-21	7530-00-285-3038	1 pkg
Paper, tracing: high transparency, white: Substance 25 to 29 per 1,000 sheets of 17 x 22 inches. Basic size 18 inches long, 12 inches wide, 100 sheets per pad 81348 UU-P-00561 type III	7530-00-235-4033	1 pad
Substance 31 to 35 per 1,000 sheets of 17 x 22 inches. Basic size 20-yd roll, 21 inches wide. 81348 UU-P-561 type III	7530-00-236-9305	1 roll
Pencil: thin lead, wood-cased, class A:		
Blue 76364 mephisto 1345	7510-00-233-2027	1 doz
Green 81348 SSP201	7510-00-264-4610	1 doz
Orange 75364 mephisto 1343	7510-00-189-7869	1 doz
Red 75364 mephisto 1340	7510-00-233-2021	1 doz
Drawing, black, w eraser, FED spec SS-P-1605 no H:		
No H	7510-00-264-4614	1 doz
No 3H	7510-00-189-7881	1 doz
No 5H	7510-00-189-7883	2 doz
General writing, black, thin lead, medium hard- ness, no 2, w eraser, 81348 SS-P-166, type IV	7510-00-281-5234	2 doz
Glazed surface marking, extra thick lead, paper-cased:		
Black, 12 per package class C	7510-00-240-1526	1 doz
Blue, 12 per package class A	7510-00-436-5210	1 doz
Red, 12 per package class B	7510-00-174-3205	1 doz

ITEM	NATIONAL STOCK NUMBER	QUANTITY
Pencil pointer: flint, 7 1/4 inches 1 1/4 inches wide, 1/8 inch thick, 81348 SS-P-551, type II	7510-00-237-4926	2 ea
Plastic sheet: cellulose acetate, transparent, matte finish 1 side, colorless, 0.0075 inch thick, 20 inches wide, 50-ft roll, 81348 L-P-504, type I	9330-00-282-8324	1 roll
Plotting needle: red head, tapered shaft, 11/16 inch long, 0.020- to 0.030-inch diameter; 1 1/8 inches long, 4 per folder (package) 81349 FF-T-51	7510-00-851-9354	12 pkg
Protractor, semicircular: brass, 4 1/4 inch, 1-degree graduations, numbered 0 to 180 degrees, 81348 GG-P-681, type I, class A, style 1	6675-00-641-3166	1 ea
Plastic; 16-inch diameter, graduation units, mils, and meters, scales 1 to 25,000 and 1 to 50,000, 10-mil graduations numbered 100 to 3,100 mils, 81349 MIL-P-20385, type I	6675-00-556-0118	1 ea
Scale, plotting: Aluminum, flat, eight bevel, hollow square shape, graduation units, meters, and yards; scales 1 to 25,000 and 1 to 50,000; 4 inches square outside and 2 inches square inside; 81349 MIL-S-10987	6675-00-283-0018	4 ea
Wood and plastic, triangular, relieved facet, graduation units, 1 to 25,000 yd, 1 to 25,000 meters, 1 to 50,000 and 1 to 62,500 inches and centimeters, 12 inches long, 81348 GG-8-161/7, shape D, notice 2	6675-00-283-0040	2 ea
Sharpener, pencil: pocket size, draftsman's point cut, 75364 catalog no 1000	7520-00-227-1451	2 ea
Shears, straight trimmers: steel blade and handle, sharp pointed blades, 9 inch, 81348 GGG-S-00278, type I, class 1, style A	5110-00-161-6912	1 ea

APPENDIX D

EMPLOYMENT OF ARMOR IN INDIRECT FIRE

D-1. PURPOSE

Although tanks are traditionally direct fire weapons, under exceptional circumstances, the force commander may decide to use them in an indirect fire role. The tank unit may be attached to the field artillery unit, or it may be given a reinforcing role. This appendix discusses the gunnery techniques to be used and other factors to be considered by the field artillery crew member when the tank unit is under field artillery control.

D-2. REQUIREMENTS

a. Because of the small bursting radius of the high-velocity, flat-trajectory ammunition and the short tube life of the main gun, tanks normally are not used in the field artillery (indirect fire) role.

b. When the tank unit is attached to or reinforcing a field artillery unit, the field artillery unit is responsible for fire control, communications, and survey. If the tank unit is attached, the field artillery unit is also responsible for ammunition, fuel, rations, and other supplies.

c. Whether attached or reinforcing, the tank unit must be able to revert immediately to its primary role. Therefore, the tank unit's basic load of ammunition should not be used in the indirect fire role. If possible, ammunition should be prestocked for this purpose.

d. For information on the mission and tactical employment of tank units, on the characteristics of tanks and tank fire control equipment, and on direct fire with tank weapons, see the 17- and 71-series field manuals.

e. The normal position area width of a tank platoon front is about 150 meters. For

tanks, a parallel sheaf produces an effective pattern of bursts with this position area width. For position areas of different widths, it is necessary to adjust the width of the sheaf to obtain the most effective pattern of bursts.

D-3. AMMUNITION

The HEP and WP projectiles are available for the 105-mm tank guns (M60, M60A1, M60A2, M60A3, M48A5, and M1 tanks). Separate fuzes are not available. All projectiles are fixed with PD fuzes.

Note. See TM 43-0001-28 for further information on ammunition.

D-4. OBSERVER PROCEDURES

Field artillery observer procedures are used in conducting indirect fire with tanks.

D-5. FIRE DIRECTION

a. Firing Chart. The location of each tank platoon is plotted on a firing chart. A deflection index is constructed at 0 deflection by orienting the left edge of the arm of the RDP in the direction on which the tanks are laid and drawing the index on the chart at the center graduation of the mil scale on the arc. The RDP is numbered for reading shifts of 500 mils right or left of the direction of lay as follows:

(1) Number the center graduation 0.

(2) Number each succeeding 100-mil graduation to the right L1 through L4 and each succeeding graduation to the left R1

through R4. The last graduation on each end need not be numbered. For reading shifts greater than 500 mils, additional indexes must be constructed. If tank weapon firing tables are not available to the FDC, the tank unit usually fires only observed fires in the indirect role. If a TFT is available, a registration should be conducted and corrections applied. Corrections sent by the observer during adjustment are plotted on the target grid as outlined in chapter 5. The armor fire control officer (FCO) will compute a range K for his weapons.

b. Fire Commands.

(1) Fire command information is sent from the FDC to the tank unit FCO, who is the tank platoon commander and is responsible for tank fire. The FCO converts this information to a platoon fire command and sends it to the tanks. The FCO requires the range from the platoon to the target, the difference in altitude, the direction, and the target description.

(a) The range information is given to the nearest 100 meters.

(b) When the target is at a different altitude from that of the tank, an angle of site is computed, in mils, and is included in the fire commands. The comp site for high-velocity guns is negligible and is ignored.

(c) The direction information is given in terms of a reference point. In the indirect fire role, the tanks are laid on an azimuth. This azimuth is considered the reference point. When the tank is laid, the azimuth indicator is zeroed, and directions are given as right or left of the reference point. Aiming posts may be set out and aligned on a common deflection (usually at 0) or 2,600 or 2,800 mils to the right front. Since the tank does not have a panoramic sight, the aiming post deflection is merely an offset angle. During lulls in the firing, the gunner checks a tank's displacement by using the aiming posts. He does not traverse the turret (tube) back to the aiming circle.

(d) The nature of the target is announced to the tanks as a portion of their fire command.

(2) Once the fire control officer has the firing information of range, altitude, direction, and target description, he must convert these data so that a fire command can be sent to the tanks.

(a) The range information must be received as a quadrant reading, which includes angle of site and the elevation corresponding to the range.

(b) The direction command must be modified so that it can be placed on the tank's fire control instruments.

(c) An example of a platoon fire command issued by the fire control officer is shown below:

PLATOON
HEP
MORTARS FIRING
3127 RIGHT
QUADRANT +430
AT MY COMMAND, FIRE

- PLATOON. The normal method of employing tanks in an indirect fire role is by platoon (five tank guns). To alert all firing weapons that they will fire, the command is PLATOON. To alert all pieces to follow with one tank firing in adjustment, the command is PLATOON ADJUST, NUMBER THREE (the number three piece firing in adjustment).
- HEP. The ammunition command is similar to that for field artillery except that the word shell is omitted.
- MORTARS FIRING. The nature of the target is announced to the tank unit as a portion of the fire command.
- 3127 RIGHT. This portion of the fire command is the direction and must be computed by the FCO by use of the direction information sent from the FDC and drift data in tank firing tables. Once the direction of the gun has been computed and drift accounted for, the data must be converted to a reading that can be applied to the tank azimuth indicator. The tank azimuth indicator is numbered left from 0 to 3,200 mils and

from that point again from 0 to 3,200 mils. Because of this, a direction and an azimuth to the left of the reference point are the same, but to the right, the two numbers are different and always total 3200. A direction **RIGHT** or **LEFT** must be included in the command, since this determines which direction along an axis the tubes point.

- **QUADRANT +430.** The FCO obtains the superelevation angle from the firing tables and combines it with the angle of site announced by the fire direction center. The tank weapons may be laid for elevation by using either the gunner's quadrant or the elevation quadrant. Since the range of most tank weapons is limited by the inability to elevate to high angles, it may be necessary either to dig in the rear of the tanks or to place the tanks on a ramp that slopes away from the direction of fire.
- **AT MY COMMAND, FIRE.** The command **AT MY COMMAND** tells the tank crew to notify the FCO when it is ready to fire. The command to open fire is **FIRE**. In tank gunnery, this command is the last element in the sequence of a fire command, because the tank gunner is trained to hold his fire until the command **FIRE** is received.

***Note.** When required, other fire commands used by the artillery (for example, pieces to fire and method of fire) are sent to the tanks in the simplest and most understandable manner. Common sense and liaison between artillery and armor should overcome difficulties caused by lack of formal procedure. These difficulties are further alleviated through the use of prearranged data sheets.*

D-5. ALTERNATE METHODS

Other methods that may be used in controlling the indirect fire of tanks are as follows:

a. Independent Method. The tank unit uses fire direction equipment and personnel organic to the tank battalion to form, with artillery assistance, a fire direction center.

b. Semi-independent Method. The tank unit handles its own indirect fire missions from prearranged data sheets. Survey control, meteorological computations, prearranged data sheets, and assistance in laying the tanks may be provided by the supported artillery. Interdiction and harassing missions are the types of missions handled most effectively by use of data sheets.

APPENDIX E

INTERNATIONAL STANDARDIZATION AGREEMENTS

E-1. DEFINITION

Standardization agreements (STANAGs and QSTAGs) are international agreements designed to facilitate allied operations. Upon ratification by the United States, these standardization agreements are binding upon the United States forces (entirely or with exceptions as noted).

E-2. STANAG

A STANAG is an international agreement wherein the nations of a specific treaty organization agree to certain operational actions to enhance the allied operation. The status of STANAGs associated with field artillery cannon gunnery, which the United States agrees to implement and promulgate, are categorized as in table E-1.

Table E-1. Standardization agreements.

STANAG	SUBJECT	STATUS
2144	Call for Fire Procedures	USAFAS changes to US-ratified STANAG 2144 are included in this publication.
2867	Radio-Telephone Procedures for the Conduct of Artillery Fire	USAFAS changes to US-ratified STANAG 2867 are included in this publication.
2875	Calls for Destruction, Smoke, Illumination, and Danger Close Missions	USAFAS changes to nonratified (draft) STANAG 2875 are included in this publication.
4119	Adoption of Standard (Common) Artillery Firing Table Format	ABCA ratified.

E-3. QSTAG

A QSTAG is an international agreement wherein the ABCA nations (United States, United Kingdom, Canada, Australia) form a quadripartite alliance and agree to certain operational and procedural techniques to enhance the allied operation. Status of QSTAGs associated with field artillery cannon gunnery, which the United States agrees to implement and promulgate, are categorized in table E-2.

Table E-2. Quadripartite standardization agreements.

QSTAG	SUBJECT	STATUS
220	Adoption of Standard (Common) Artillery Firing Table Format	ABCA ratified.
224	Manual Fire Direction Equipment, Target Classification, and Methods of Engagement for Post-1970	ABCA ratified.
225	Call for Fire Procedures	USAFAS changes to US-ratified QSTAG 225 are included in this publication.
246	Radio-Telephone Procedures for the Conduct of Artillery Fire	USAFAS changes to US-ratified QSTAG 246 are included in this publication.

E-4. IMPLEMENTATION

The doctrine, procedures, and techniques promulgated in the above STANAGs and QSTAGs are implemented in this publication only as indicated in the status shown for each STANAG/QSTAG. As ratification details occur, specifically concerning those agreements that have been changed by USAFAS, subsequent implementation and promulgation action will be made accordingly. Tables E-3 through E-6 are examples of basic cannon gunnery procedures as promulgated in the various QSTAGs and STANAGs and are included here to allow member nation units to operate with United States Army units when this publication is the only reference available.

Table E-3. Example of call for fire other than US.

SERIAL	GENERAL HEADING	SPECIFIC EXAMPLE
1	Observer's identification	20, THIS IS 21
2	Warning order	FIRE MISSION BATTERY
3	Location of target including direction	GRID 123456 ALTITUDE 100 DIRECTION 1640
4	Target description	PLATOON DUG IN ON RIDGE 200 BY 50, ATTITUDE 4850
5	Method of engagement a. Type of engagement b. Trajectory c. Ammunition d. Distribution of fire	DANGER CLOSE HIGH ANGLE VT IN EFFECT 10 ROUNDS OPEN
6	Method of fire and control	AT MY COMMAND TWO GUNS PLATOON RIGHT ADJUST FIRE

Table E-4. Example of US call for fire.

SERIAL	GENERAL HEADING	SPECIFIC EXAMPLE
1	Observer's identification	A57, THIS IS A71
2	Warning order	ADJUST FIRE, SHIFT AB2176
3	Location of target	DIRECTION 5210, LEFT 380, ADD 400, DOWN 25
4	Target description	PLATOON DUG IN ON RIDGE 200 BY 50, ATTITUDE 1650
5	Method of engagement a. Type of engagement b. Trajectory c. Ammunition d. Distribution of fire	DANGER CLOSE HIGH ANGLE VT IN EFFECT 10 ROUNDS ¹ OPEN
6	Method of fire and control	TWO GUNS AT MY COMMAND
¹ US observer will not specify number of rounds.		

Table E-5. Example of an area target engaged by a battery of US artillery when the observer is from another member nation.

SERIAL	OBSERVER'S REQUEST	REPORTS TO OBSERVER
1	(Observer's identification)	
2	FIRE MISSION	
3	GRID 321456, ALTITUDE 120	
4	DIRECTION 5100	
5	VEHICLES PARKED IN WOODS 200 BY 100, ATTITUDE 2850	
6	ADJUST FIRE	
7		(Battery identification), 6 ROUNDS ZP7115
8		SHOT
9	RIGHT 100, ADD 400	
10		SHOT
11	DROP 200	
12		SHOT
13	DROP 100	
14		SHOT
15	DROP 50, FIRE FOR EFFECT	
16		SHOT ROUNDS COMPLETE
17	END OF MISSION. THREE VEHICLES BURNING	

Table E-6. Example of an area target engaged by a battery of artillery (not US) when the observer is from the US.

SERIAL	OBSERVER'S REQUEST	REPORTS TO OBSERVER
1	(Observer's identification)	
2	ADJUST FIRE	
3	GRID 321456	
4	SIX ARMORED PERSONNEL CARRIERS	

Table E-6. Example of an area target engaged by a battery of artillery (not US)
when the observer is from the US (continued).

SERIAL	OBSERVER'S REQUEST	REPORTS TO OBSERVER
5		<i>(Battery identification)</i> 6 ROUNDS
6		SHOT
7	DIRECTION 1680, RIGHT 120, ADD 400	
8		SHOT
9	DROP 200	
10		SHOT
11	DROP 100	
12		SHOT
13	ADD 50, FIRE FOR EFFECT	
14		SHOT
15	END OF MISSION, TWO PERSONNEL CARRIERS DESTROYED	ROUNDS COMPLETE

APPENDIX F

STANDARDIZED PROCEDURES

F-1. IDENTIFICATION

This appendix contains the following standardized procedures relevant to cannon fire direction:

SUBJECT	PAGE
Surveyed Firing Charts	5-1
Firing Chart Numbering	
Positioning and Orienting the Target Grid	
Plotting Points on the Firing Chart	
Target Symbiology on Firing Charts	
Establish Azimuth Indexes on Firing Charts	
Establish Deflection Indexes on Firing Charts	
Determine Initial Chart Data	
Elements and Format for Announcing Chart Data	
Chart Data Tolerances	
Manual Chart Verification	
Muzzle Velocity Management	11-1
M90 Velocimeter Work Sheet	
Muzzle Velocity Record	
Muzzle Velocity Log	
Computer's Checklist	13-4
Ammunition Status	
Weapons Data	
Planned Firing Data	
Prepare and Update Firing Charts	G-1
Attack Targets	G-4
Determine and Apply Registration Corrections	G-7
Initialize BCS for Operation	G-10
Determine Replot Data	G-12
Determine and Apply Met Corrections	G-14
Establish and Maintain Communications	G-17
Prepare for Dedicated Battery Operations	G-21
Manage and Apply Muzzle Velocity Information	G-23
Initialize the Hand-Held Calculator for Operation	G-24
Initialize FADAC for Operations	G-26
Determine Special Corrections	G-28

Note. The above procedures are denoted by an asterisk (*) in the text.

F-2. APPROVED FDC LAYOUTS

Included in this appendix are the approved layouts of the battery FDCs in the M577 and M561 command post vehicles. Detailed drawings and discussions are available from:

Commandant
US Field Artillery School
ATTN: ATSF-GA
Fort Sill, OK 73503

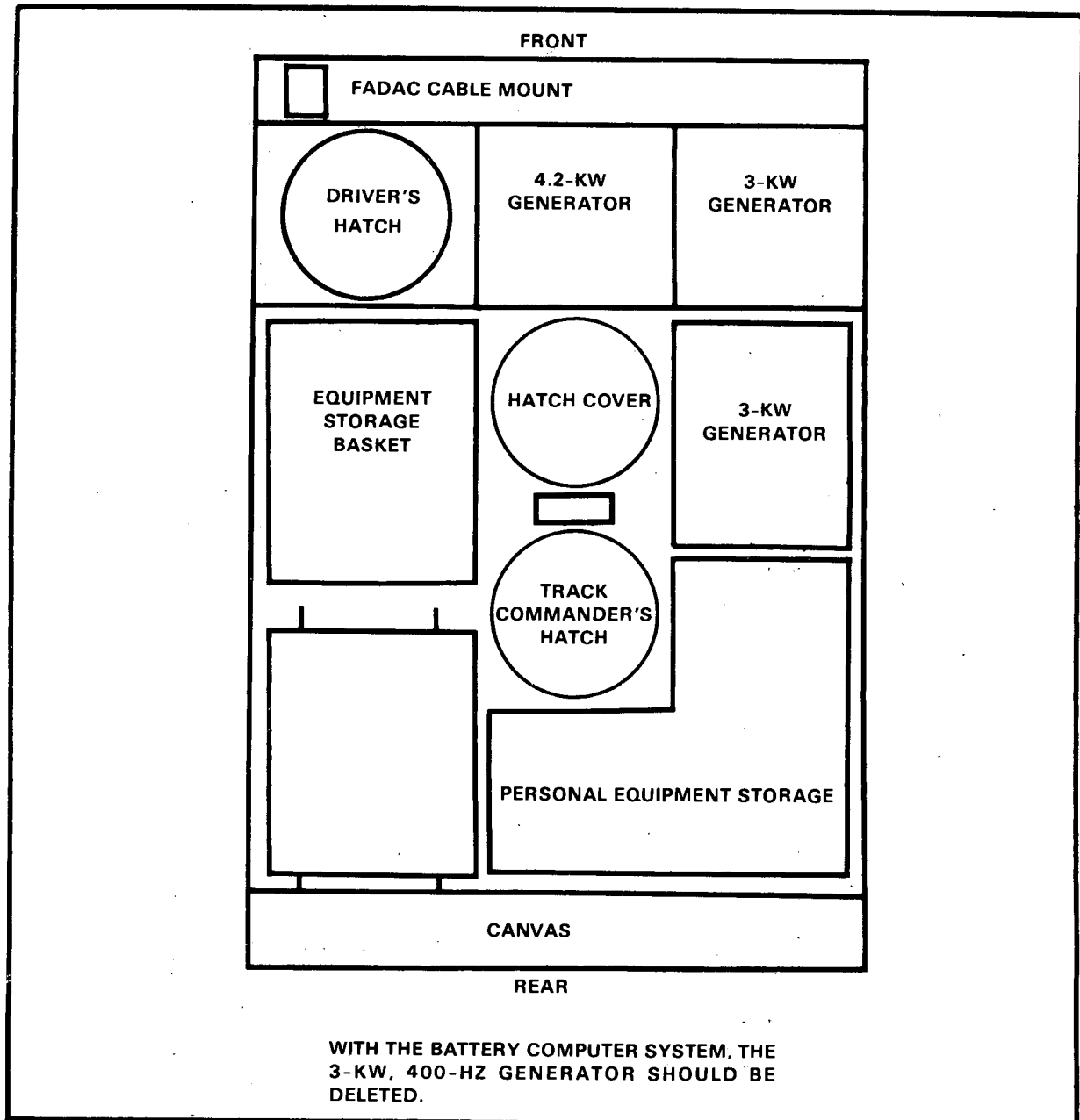


Figure F-1. External top view of battery FDC in M577A1 command post vehicle.

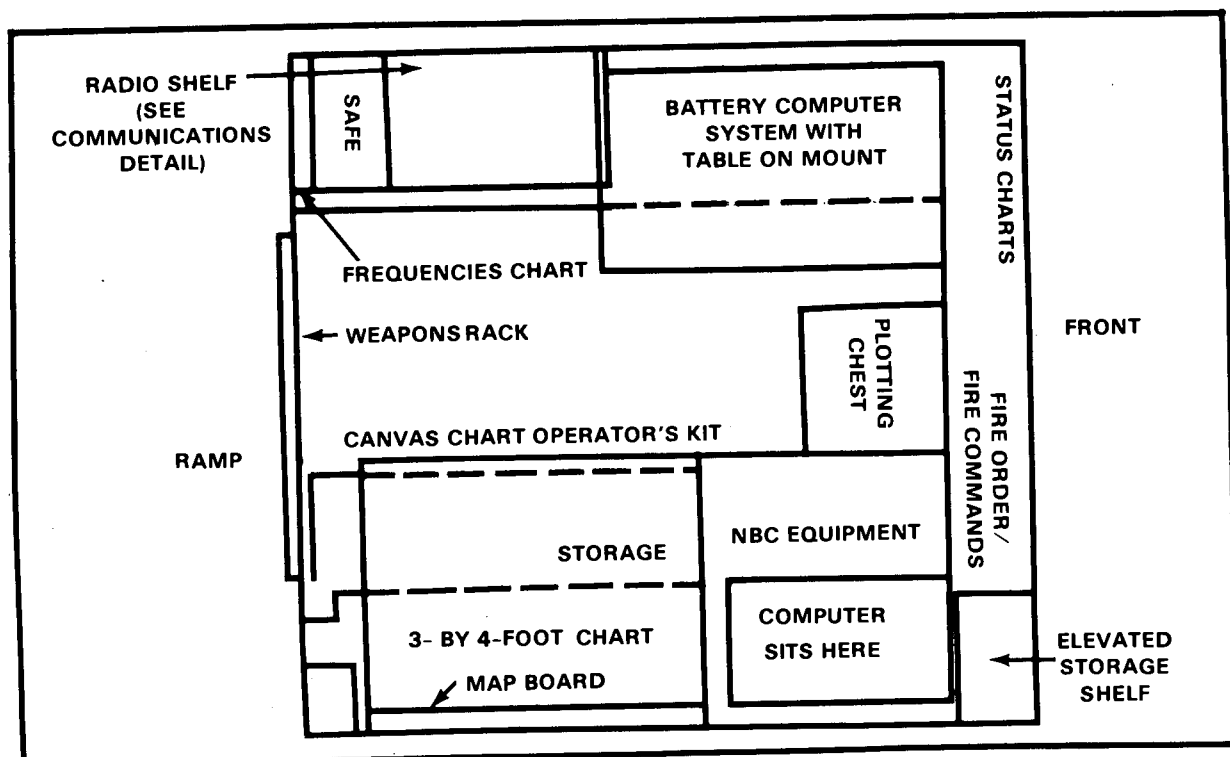


Figure F-2. First tier of BCS-equipped battery FDC in M577A1 command post vehicle.

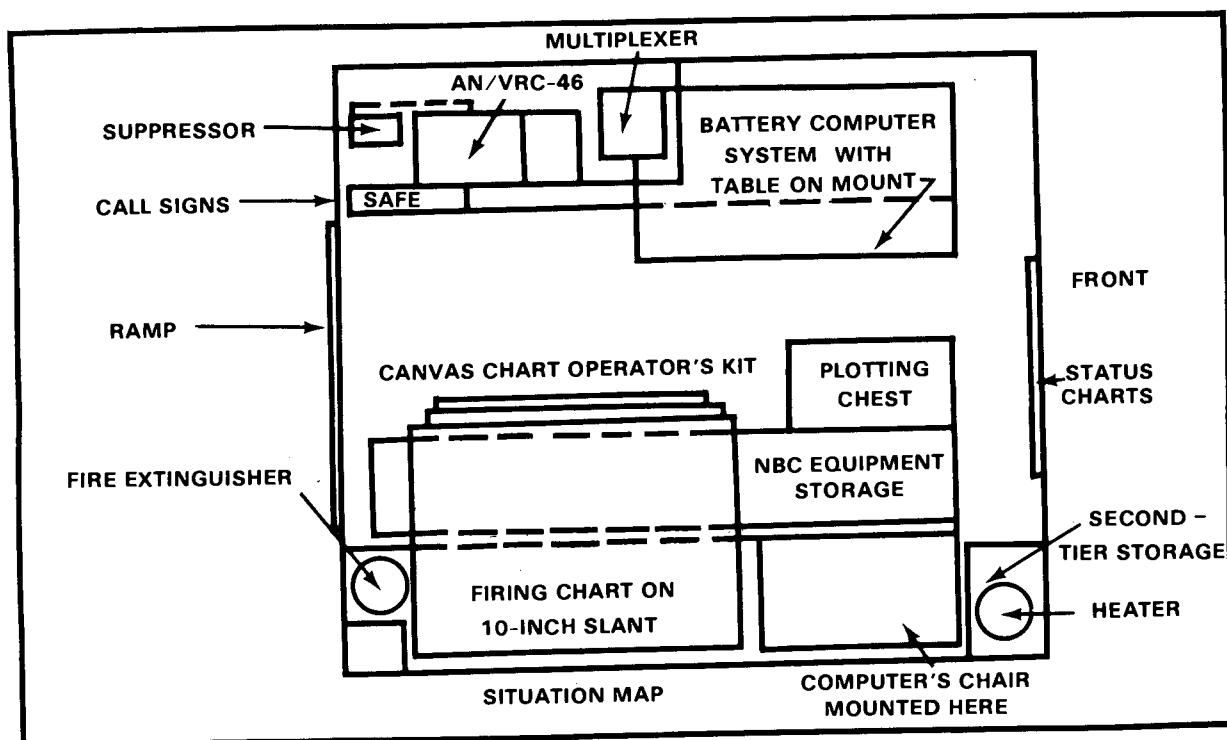


Figure F-3. Second tier of BCS-equipped battery FDC in M577A1 command post vehicle.

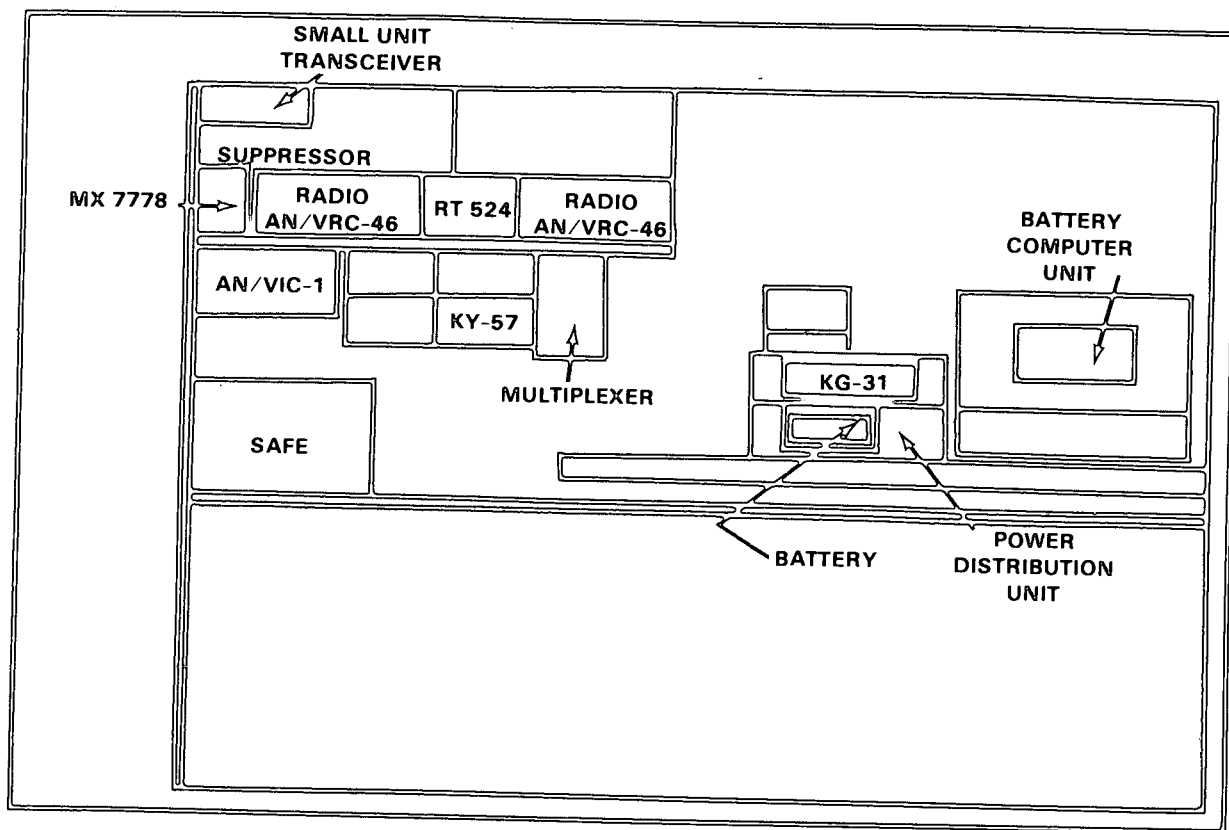


Figure F-4. Left side view of BCS-equipped battery FDC in M577A1 command post vehicle.

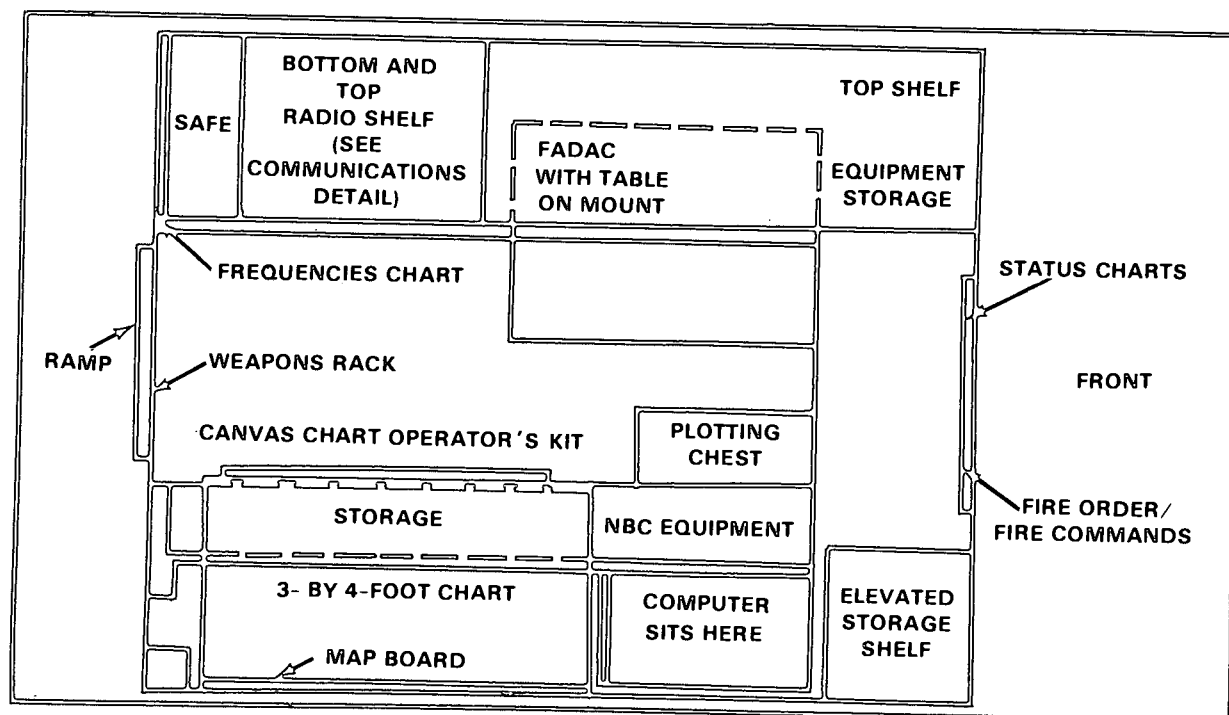


Figure F-5. First tier of FADAC-equipped battery FDC in M577A1 command post vehicle.

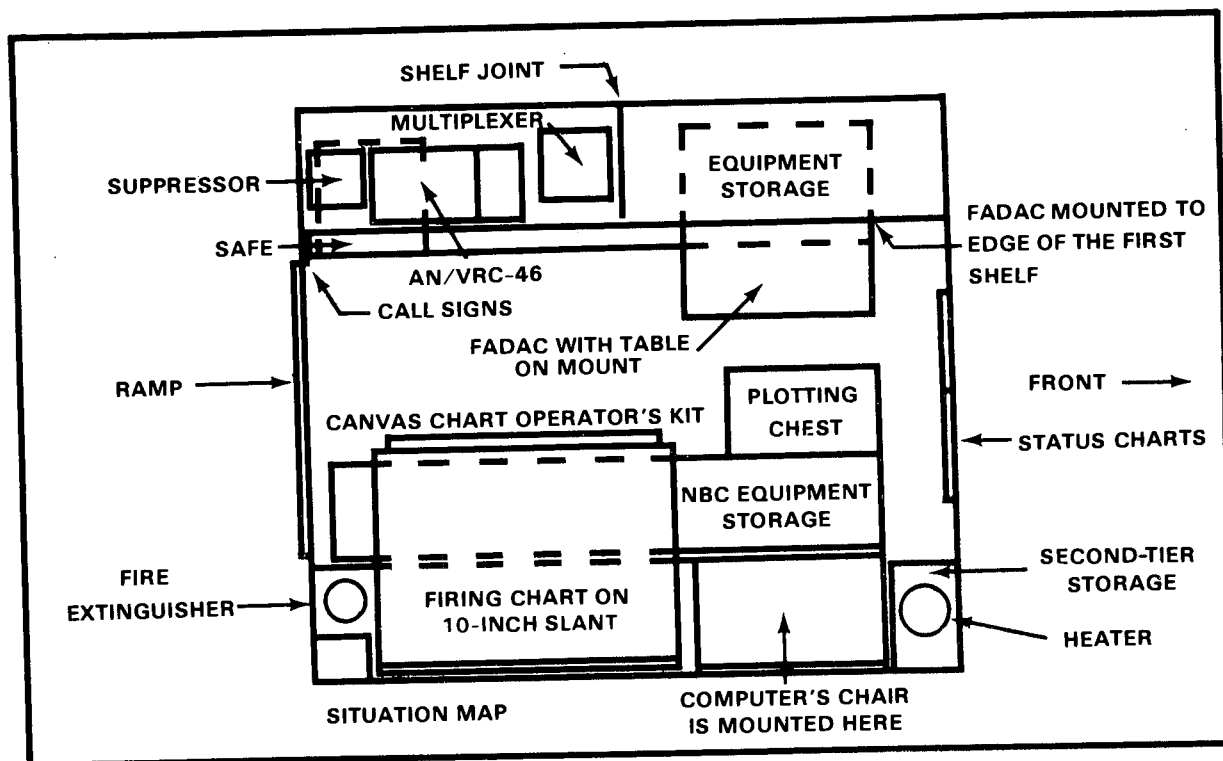


Figure F-6. Second tier of FADAC-equipped battery FDC in M577A1 command post vehicle.

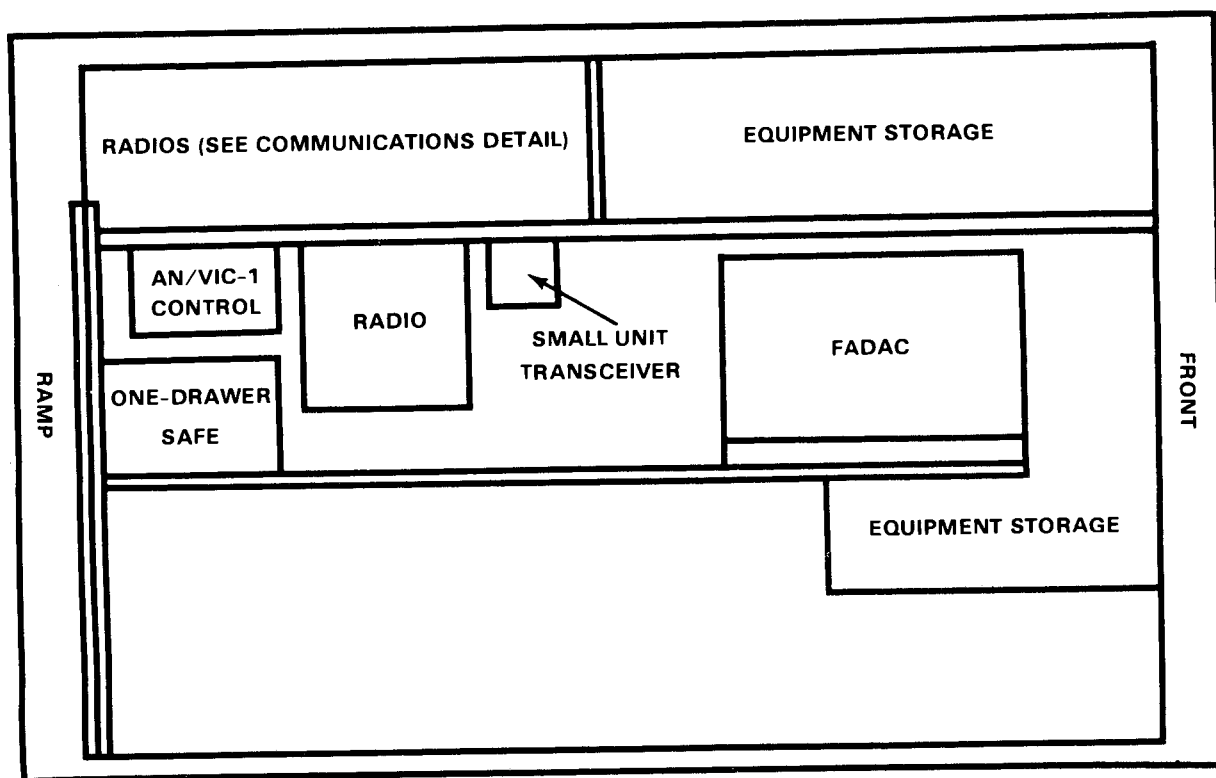


Figure E-7. Left side view of FADAC-equipped battery FDC in M577A1 command post vehicle.

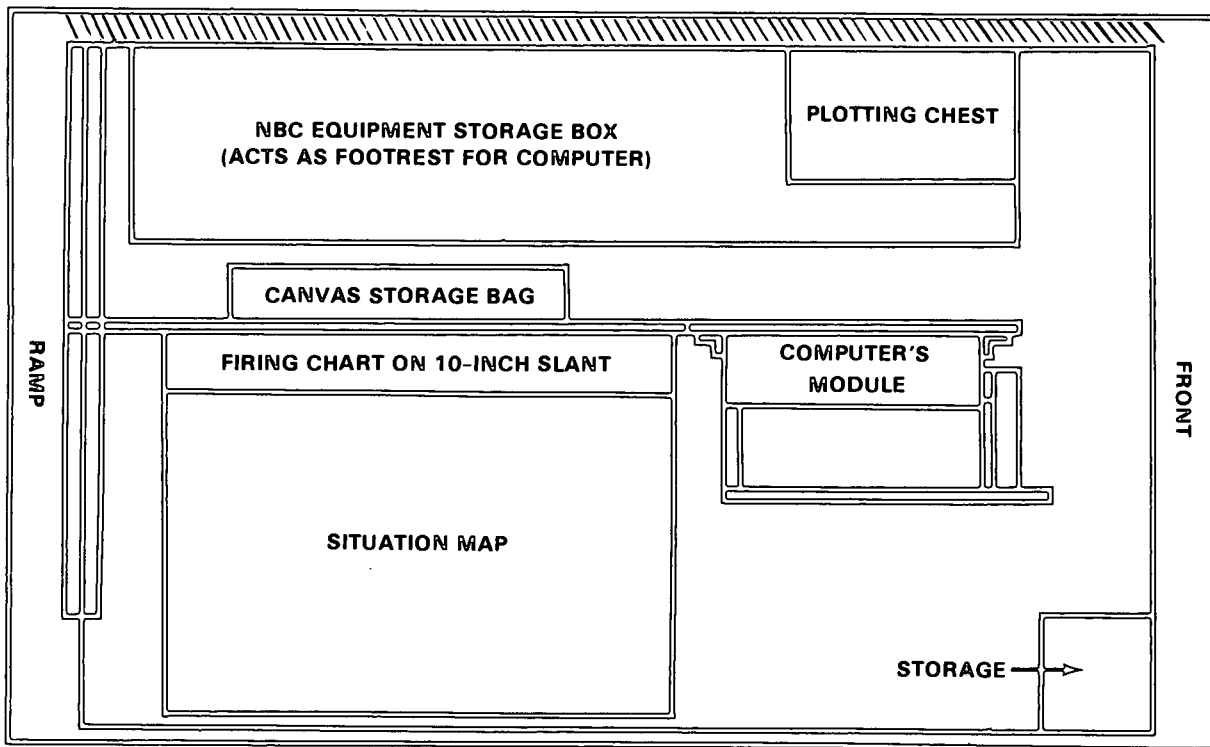


Figure F-8. Right side view of BCS- or FADAC-equipped battery FDC in M577A1 command post vehicle.

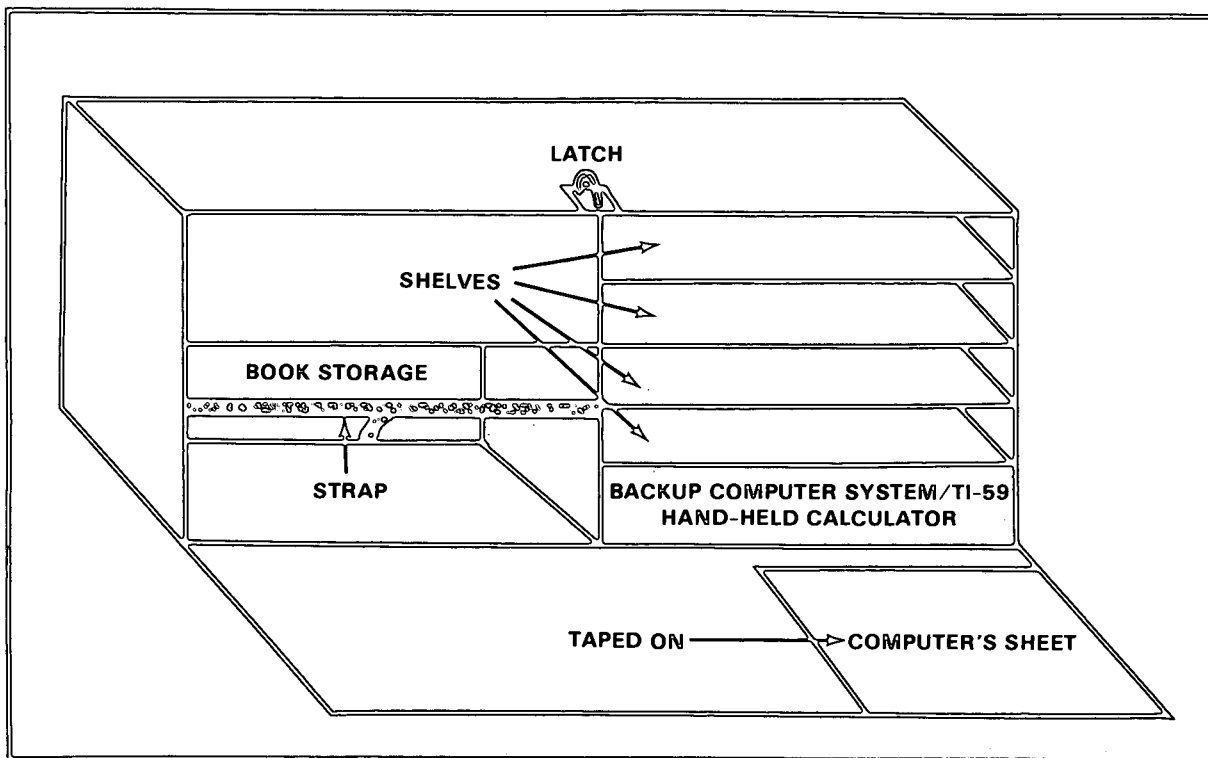


Figure F-9. Sample computer's desk made from a footlocker for M561 command post vehicle.

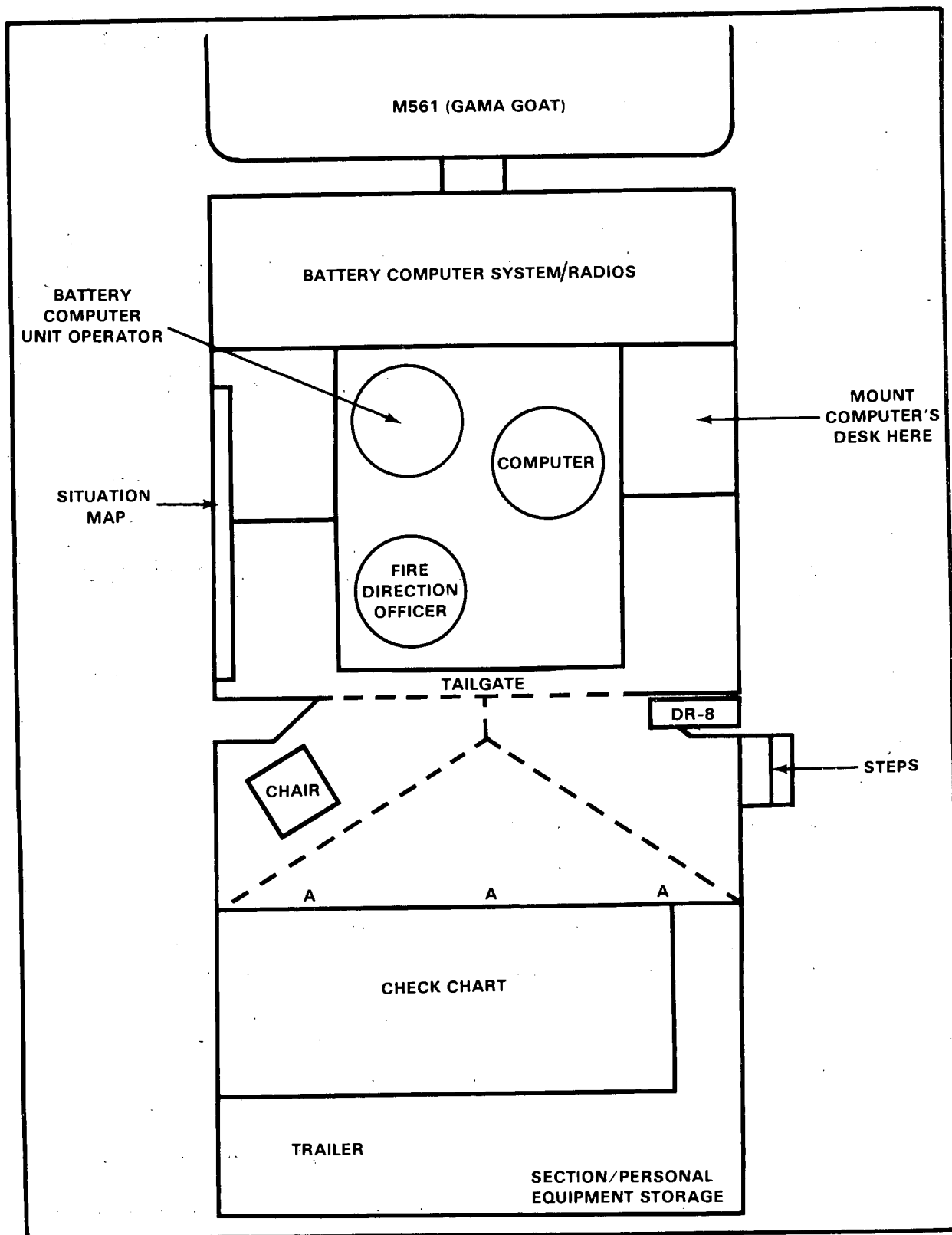


Figure F-10. Top view of BCS-equipped battery FDC in M561 command post vehicle.

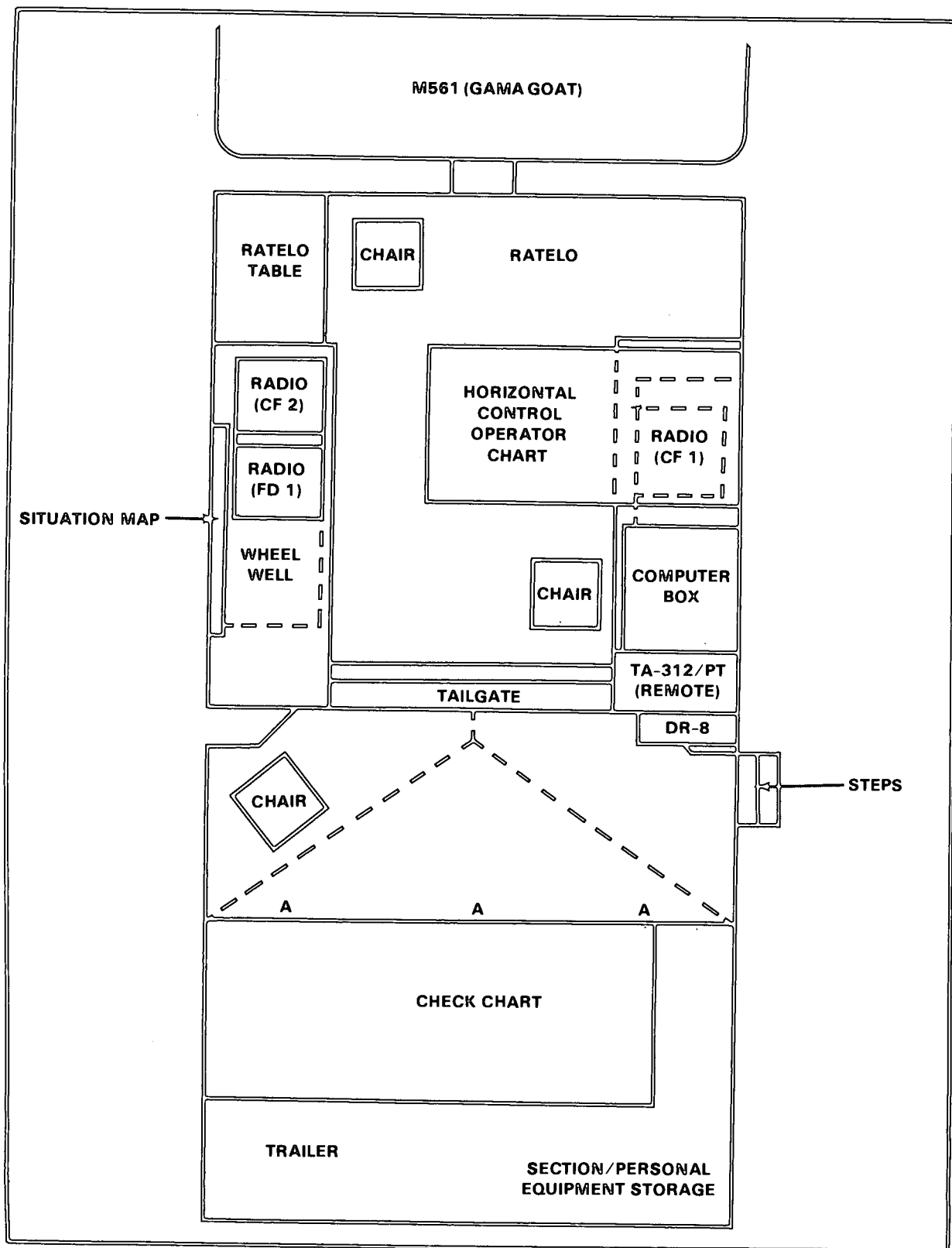


Figure F-11. Top view of manual FDC in the M561 command post vehicle.

Appendix G

HOW TO TRAIN FIRE DIRECTION CENTER PERSONNEL

G-1. RESPONSIBILITY

Training the FDC personnel involves teaching and sustaining proficiency in individual and collective skills that the FDC needs to accomplish its mission. The commander is responsible for developing and implementing the best mix of individual and collective training that will help soldiers learn and sustain proficiency in the required skills. The levels of training are as follows:

- a.* Field training exercise (FTX)—a live-fire exercise.
- b.* Situational training exercise (STX)—an ARTEP task.
- c.* Crew drill—an ARTEP subtask (a collective training task).
- d.* Individual task—a soldier's manual task.

G-2. FDC CREW DRILLS

a. Crew training drills provide a unit with practical and efficient methods to facilitate and integrate individual and collective training. These drills consist of standardized techniques and procedures that facilitate the performance of the subtask.

b. Drills have traditionally been used as an effective method of integrating individual and leader skills at the lowest echelon to enable personnel to perform collective tasks. Drills are considered the most effective method of training FDC subtasks, because drills reinforce individual task proficiency while preparing the FDC section for more complex collective tasks.

c. The following crew drills have been prepared by the United States Army Field Artillery School. They are included as a source for training. Other drills may be

developed by the unit to meet training guidance provided by the commander. The drills may be trained in garrison and in the field. Wherever trained, these drills offer many advantages such as the following:

- (1) They assist inexperienced junior leaders to plan, prepare, and implement training.
- (2) They allow soldiers to practice their individual skills and teach them how, when, and where to use these skills during unit performance of ARTEP tasks.
- (3) They minimize training costs and resources.

*G-3. PREPARE AND UPDATE FIRING CHARTS

a. General. This drill is an integral part of the battalion training system and was developed from the ARTEP and soldier's manuals. It trains ARTEP 6-100 subtask 3-I-6-1b. It applies to all FADAC/manual units.

b. Prerequisites. Certain crew drills, ARTEP tasks, and individual skills must be mastered before this drill can be trained. The pretraining requirements include the following:

- (1) ARTEP subtask: 3-I-6-1
- (2) Individual soldier's manual tasks:
061-280-1000
061-280-1001
061-280-1004
- (3) References:
ARTEP 6-100
FM 6-13E1/2/3

c. Practice. Following pretraining, the section must practice this drill to achieve initial proficiency. After initial proficiency has been achieved, sustainment training every 4 months is recommended. More frequent training may be necessary if the unit has a high turnover of personnel, infrequent related training, loss of key personnel such as chief computer/computer, or unit-peculiar problems that degrade drill proficiency.

d. Recommended Training Support.

(1) **Personnel and equipment.** A battery FDC section TOE and a battery FDC section crew are required to train this drill.

(2) **Time requirements.** It is estimated that the battery FDC section crew will require 2 hours of initial training and 30 minutes of sustainment training.

(3) **Training area requirements.** Each FDC section undergoing training will require a 50- by 50-meter area for emplacement of the section vehicle or for a classroom of sufficient size to accommodate the TOE equipment and the crew.

(4) **Standards.** The drill standards are based on the following assumptions:

(a) All TOE personnel and equipment are available and operational.

(b) All personnel are MOS-qualified.

(c) Unless otherwise specified in the conditions, no other competing actions are ongoing, and weather conditions are favorable.

e. Training Procedures. The chief computer will have the FDC crew occupy the training area. When this has been done, he will immediately direct the section to prepare the firing chart.

(1) **Preparing the firing chart.** To be proficient at this task, the section should be trained to construct firing charts when survey control is available and when survey control is not available, but a map is available. The chief computer will provide plotting sheets, plotting equipment, and pertinent data. Time and drill sequence will begin when the section has occupied the position/training area.

(2) **Updating the firing chart.** The update phase of the drill will follow the preparation phase. The section should be trained to update firing charts on the basis of the following conditions:

(a) Survey control is brought to the battery location after a map spot has been established.

(b) The battery is required to maintain a 6,400-mil firing capability.

(3) **Evaluation.** The chief computer evaluates the actions of the section and notes all training deficiencies and omissions. An after-action review is given to the FDC section after the drill has been completed. The drill is trained until no deficiencies are noted by the chief computer.

Table G-1. Prepare and update firing charts drill.

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
	Battery has occupied a position area. Plotting sheets and plotting equipment are available.	Number the grid on the firing chart. Plot known critical points; for example, OPs, battery locations, and radars. Construct azimuth and deflection indexes. Verify firing chart construction. $\pm 3^\circ$ deflection/azimuth ± 30 meters range

Table G-1. Prepare and update firing charts drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
CHIEF COMPUTER		This drill should be completed within 8 minutes of occupation of the position to allow the section to process calls for fire.
Issue order to prepare/update firing charts.	The FDC section and equipment are in position and are occupying the battery area.	During occupation of position, direct the personnel to establish and maintain the FDC. Firing charts should be prepared as soon as possible. Organize the section beforehand to ensure rapid and orderly occupation. Assign duties and ensure that tasks are understood. Assign section priorities for preparation. Ensure section members are thoroughly familiar with unit and section SOPs.
Verify the preparation of firing charts.	The FDC section and equipment are positioned, and charts are being prepared.	Ensure chart operators have the correct data. Announce the coordinates found in the lower left-hand corner of the chart. Ensure firing charts are constructed properly. Ensure FADAC/chart verification is performed.
HCO		
If FADAC is not available, construct a firing chart.	You will be given— ◦ A grid sheet. ◦ The number for the lower left-hand corner of the chart. ◦ The coordinates and altitudes of three firing batteries and other critical points. ◦ The azimuth of lay and referred deflection information for the batteries. ◦ An RDP. ◦ An aluminum plotting scale. ◦ Plotting pins. ◦ Pencils and an eraser. ◦ A map indicating the zone of action of the supported unit.	Number the grid lines for easting and northing. Plot, tick mark, and label locations within ± 30 meters of the true location. Construct and label the primary deflection index for each of the firing batteries within ± 3 mils. Construct and label azimuth indexes for OPs and radars within ± 3 mils. Verify firing chart construction. Set up the chart within 8 minutes of receipt of information for the battery. Complete the firing chart for all locations within 14 minutes.
Transfer from a map-spotted firing	You will be given all chart information including surveyed grid coordinates and altitudes,	Transfer from a map-spotted firing chart to a surveyed firing chart without error within 8 minutes.

Table G-1. Prepare and update firing charts drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
chart to a surveyed firing chart.	the range and range to the fired-on targets, and the new azimuth of fire.	Note. If FADAC is not available in the FDC, the HCO will construct and maintain the primary firing chart and determine chart data. If FADAC is available, the HCO will operate the FADAC.
VCO		
Construct a firing chart.	You will be given—	Number the grid lines for easting and northing.
Transfer from a map-spotted firing chart to a surveyed firing chart.	◦ A grid sheet. ◦ The number for the lower left-hand corner of the chart. ◦ The coordinates and altitudes of three firing batteries and other critical points. ◦ The azimuth of lay and referred deflection information for the batteries. ◦ An RDP. ◦ An aluminum plotting scale. ◦ Plotting pins. ◦ Pencils and an eraser. ◦ A map indicating the zone of action of the supported unit.	Plot, tick mark, and label locations within +30 meters of the true location.
		Construct and label the primary deflection index for each of the firing batteries within +3 mils.
		Construct and label azimuth indexes for OPs and radars within +3 mils.
		Verify firing chart construction.
		Set up the chart within 8 minutes of receipt of information for the battery. Complete the firing chart for all locations within 14 minutes.
	You will be given all chart information including surveyed grid coordinates and altitudes, the range and range to the fired-on targets, and the new azimuth of fire.	Transfer from a map-spotted firing chart to a surveyed firing chart without error within 8 minutes.
		Note. If FADAC is not available in the FDC, the VCO's chart becomes the check chart. The VCO determines site. If FADAC is available, the VCO's chart becomes the only chart and will be used in conjunction with FADAC in the fastest method for data determination.

***G-4. ATTACK TARGETS**

a. General. This drill is an integral part of the battalion training system and was developed from the ARTEP and soldier's manuals. It trains ARTEP 6-100 subtask 3-I-6-2 or 3-I-6-7. It applies to all units.

b. Prerequisites. Certain crew drills, ARTEP tasks, and individual skills must be mastered before this drill can be trained. The pretraining requirements include the following:

(1) ARTEP subtask: 3-I-6-3 or 3-I-6-8

(2) Individual soldier's manual tasks:

061-280-1001

061-280-1010

061-280-1020

061-281-1001

061-281-2001

(3) References:

ARTEP 6-100

FM 6-13E1/2/3

FM 6-141-1

FM 6-141-2

FM 101-60 series

c. Practice. Following pretraining, the section must practice this drill to achieve initial proficiency. After initial proficiency has been achieved, sustainment training every 4 months is recommended. More frequent training may be necessary if the unit has a high turnover of personnel, infrequent related training, loss of key personnel such as chief computer/computer, or unit-peculiar problems that degrade drill proficiency.

d. Recommended Training Support.

(1) **Personnel and equipment.** A battery FDC section TOE and a battery FDC section crew are required to train this drill.

(2) **Time requirements.** It is estimated that the battery FDC section crew will require 4 hours of initial training and 1 to 2 hours of sustainment training.

(3) **Training area requirements.** Each FDC section undergoing training will require a 50- by 50-meter area for emplacement of the section vehicle or for a

classroom of sufficient size to accommodate the TOE equipment and the crew.

(4) **Standards.** The drill standards are based on the following assumptions:

(a) All TOE personnel and equipment are available and operational.

(b) All personnel are MOS-qualified.

(c) Unless otherwise specified in the conditions, no other competing actions are ongoing, and weather conditions are favorable.

e. Training Procedures. To train this drill, the chief computer will have the FDC crew occupy the training area. The chief computer evaluates the actions of the section and notes all training deficiencies and omissions. An after-action review is given to the FDC section upon completion of the drill. The drill is trained until no deficiencies are noted by the chief computer.

Table G-2. Attack targets drill.

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Fire Direction Officer	A fire mission has been received. Commander's target attack guidance, weapon/ammunition status, and situation are known. The level of control has been established. Fire order standards have been posted.	Maintain current weapon, ammunition, and situation information. Determine whether or not to attack the target. Determine effects desired and munitions required.
Determine method of target attack.	Target location and description have been received. Commander's attack guidance is known.	Use the GMET or JMEM to determine the following: ◦ Precedence of attack. ◦ Desired effects. ◦ Most suitable ammunition. ◦ Most suitable method of engagement. ◦ Aiming points needed.
Issue battery fire order.	Target attack analysis has been completed. Battery fire order standards have been designated.	Issue complete fire order specifying any changes from the fire order standards.
Process battalion fire order (FADAC/manual).	Battery has received a battalion fire order.	Issue the battery fire order.

Table G-2. Attack targets drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Chief Computer Supervise target attack.	Fire order has been issued.	Direct and supervise personnel during fire mission processing. Ensure the section computes firing data in accordance with the fire order by use of the appropriate source (BCS, FADAC, or manual). Ensure fire commands are issued correctly. Ensure firing data are computed correctly. Ensure message to observer is sent correctly. Ensure subsequent corrections are processed correctly.
Computer Issue fire commands to the howitzer section. Determine and announce firing data.	Fire order has been issued. Fire command standards are posted. Fire mission is in progress. Chart data are announced.	Issue fire commands in the correct sequence. Determine initial firing data for adjusting piece or center platoon (FFE) within 30 seconds. Announce fire commands. Determine subsequent corrections to firing data, and announce subsequent fire commands/FFE commands (include special corrections).
FADAC/HHC Operator Determine and announce firing data.	Fire mission is in progress.	Determine and announce firing data to the computer.
HCO/VCO Determine chart data.	Fire mission is in progress.	Plot the target or subsequent corrections. Determine and announce chart range. Determine and announce chart deflection. Measure and announce angle T if OT direction is given or if it changes.
Determine site.	Computer requests site.	Determine and announce site within 1 minute.
RATELO Transmit the message to observer.	Fire mission is in progress.	Determine and transmit the message to observer.

*G-5. DETERMINE AND APPLY REGISTRATION CORRECTIONS

a. General. This drill is an integral part of the battalion training system and was developed from the ARTEP and soldier's manuals. It trains ARTEP 6-100 subtask 3-I-6-1d. It applies to all FADAC/manual units.

b. Prerequisites. Certain crew drills, ARTEP tasks, and individual skills must be mastered before this drill can be trained. The pretraining requirements include the following:

- (1) ARTEP subtask: 3-I-6-3a
- (2) Individual soldier's manual tasks:
 - 061-280-1103 061-280-2009
 - 061-280-1104 061-280-2702
 - 061-280-2003 061-281-1006
 - 061-280-2004 061-281-1009
 - 061-280-2005 061-281-1104
 - 061-280-2006 061-281-1702
 - 061-280-2007 061-282-2006
- (3) References:
 - ARTEP 6-100
 - FM 6-13E1/2/3
 - FM 6-30

c. Practice. Following pretraining, the section must practice this drill to achieve initial proficiency. After initial proficiency has been achieved, sustainment training every 4 months is recommended. More frequent training may be necessary if the unit

has a high turnover of personnel, infrequent related training, loss of key personnel such as chief computer/computer, or unit-peculiar problems that degrade drill proficiency.

d. Recommended Training Support.

(1) **Personnel and equipment.** A battery FDC section TOE and a battery FDC section crew are required to train this drill.

(2) **Time requirements.** It is estimated that the battery FDC section crew will require 4 hours of initial training and 1 to 2 hours of sustainment training.

(3) **Training area requirements.** Each FDC section undergoing training will require a 50- by 50-meter area for emplacement of the section vehicle or for a classroom of sufficient size to accommodate the TOE equipment and the crew.

(4) **Standards.** The drill standards are based on the following assumptions:

(a) All TOE personnel and equipment are available and operational.

(b) All personnel are MOS-qualified.

(c) Unless otherwise specified in the conditions, no other competing actions are ongoing, and weather conditions are favorable.

e. Training Procedures. To train this drill, the chief computer will have the FDC crew occupy the training area. The chief computer evaluates the actions of the section and notes all training deficiencies and omissions. An after-action review is given to the FDC section upon completion of the drill. The drill is trained until no deficiencies are noted by the chief computer.

Table G-3. Determine and apply registration corrections drill.

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
	The battery has registered. Adjusted data have been determined.	Manual—Determine GFT setting and deflection corrections within 2 minutes of receipt of adjusted data and end of mission of the registration. Send GFT settings to battalion FDC (if applicable). FADAC—Determine, record, and apply FADAC residuals within 4 minutes of receipt of adjusted data.

Table G-3. Determine and apply registration corrections drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
		Determine multiplot GFT settings and deflection corrections within 2 minutes of applying FADAC registration residuals. Send GFT settings/residuals to battalion FDC (if applicable). HHC—Determine, record, and apply HHC registration corrections within 4 minutes of receipt of the manual GFT setting. Manual—Using survey data, determine new chart data to the registration point. Recompute site. Determine new adjusted elevation and total deflection correction. Determine new adjusted time if corrected VI is greater than 100 meters. Determine new GFT setting within 3 minutes of receipt of survey data. FADAC—Enter survey data into FADAC. Determine and apply new FADAC residuals. Using FADAC, derive a new multiplot GFT setting within 4 minutes of receiving survey data. HHC—Determine, record, and apply HHC registration corrections within 4 minutes of receipt of the manual GFT setting.
Chief Computer		
Issue order to prepare/update GFT settings/computer residuals.	The battery has registered. Adjusted data have been determined.	Direct and supervise personnel during determination and application of registration. BCS residuals should be determined and applied within 2 minutes of receipt of adjusted data. FADAC and HHC registration residuals should be determined within 4 minutes of receipt of adjusted data. Organize the section beforehand to ensure rapid, accurate, and orderly computation. Assign duties and ensure tasks are understood. Ensure section members are thoroughly familiar with unit and section SOPs.
Verify the preparation of registration corrections.	Registration corrections are being determined and applied.	Ensure computer has correct adjusted data and is applying the data correctly in the computations. Ensure the FADAC and HHC operators have the correct adjusted data and are applying the data correctly. Assign ranges for multiplot GFT settings.

Table G-3. Determine and apply registration corrections drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Computer		Ensure GFT settings check at the met check gage points; verify between GFTs. Ensure GFT settings are prepared and transmitted to battalion FDC (if applicable).
Determine and apply GFT settings and deflection corrections to graphical equipment.	A registration has been conducted. Adjusted firing data and chart data are known.	Determine and apply GFT setting without error within 2 minutes of receipt of adjusted data. Determine the GFT settings in the proper sequence. Determine the total deflection correction. Determine the GFT deflection correction. Apply the GFT setting to the GFT. Announce the GFT setting to the GFT fan operator.
Determine a new GFT setting when transferring from a map-spot firing chart to a surveyed firing chart.	Survey data not available at the time of registration are now available.	Determine and apply new GFT setting and GFT deflection correction without error within 3 minutes of receipt of survey chart data to the registration point. Determine the new adjusted elevation. Determine the new total deflection correction. Determine the GFT deflection correction. Apply the GFT setting to the GFT. Announce the GFT setting to the GFT fan operator.
Determine total corrections from a registration.	The battery has registered. The GFT setting and initial chart data to the registration point are known.	Determine total corrections without error within 3 minutes. Determine total range correction. Determine total deflection correction. Determine total fuze correction. Determine and apply the second-lot GFT setting without error within 4 minutes.
Determine a GFT setting for a second-lot registration.	A second propellant lot has been registered with the first lot. Adjusted data and total fuze correction from the first-lot registration, the site, and the chart range to the final pin location on the firing chart from the second-lot registration are known.	Determine the adjusted deflection. Determine the adjusted elevation. Determine the adjusted time. Determine the second GFT setting in the proper sequence and apply it to the GFT.
FADAC Operator		
Using FADAC, compute, store, and transfer registration	FADAC is prepared for action. All known data are entered. A registration is being conducted.	Compute, store, and transfer registration corrections without error within 4 minutes of receipt of adjusted data.

Table G-3. Determine and apply registration corrections drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
corrections. Derive adjusted data for a multiplot GFT setting. HHC Operator Using the computer set, FA general, compute and store registration corrections. Chart Operator Determine and announce chart data. Determine and announce site.	Registration corrections are stored in FADAC. Ranges to two met check gage points are announced. You have set up the HHC for action. A GFT setting is announced. A registration is being conducted. The computer requests site.	Determine firing data for the adjustment of the registration, and end the mission. Determine registration corrections. Store registration corrections as directed, and transfer corrections to nonregistering fire units. Derive adjusted data for a multiplot GFT setting without error within 4 minutes. Compute and store registration corrections (residuals) without error within 4 minutes. Determine and store range K. Determine and store deflection correction. Determine and store fuze K. Determine and announce chart data for initial, adjusting, and final corrections. Determine and announce site as requested.

*G-6. INITIALIZE BCS FOR OPERATION

a. General. This drill is an integral part of the battalion training system and was developed from the ARTEP and soldier's manuals. It trains ARTEP 6-100 subtask 3-I-6-6. It applies to all BCS-equipped units.

b. Prerequisites. Certain crew drills, ARTEP tasks, and individual skills must be mastered before this drill can be trained. The pretraining requirements include the following:

(1) ARTEP subtask: 3-I-6-6

(2) References:

FM 6-1

FM 6-50

FM 24-1

FM 24-18

TM 11-5985-357-13

TM 11-7440-283-12-1

STANAG 2867

c. Practice. Following pretraining, the section must practice this drill to achieve initial proficiency. After initial proficiency has been achieved, sustainment training every 4 months is recommended. More frequent training may be necessary if the unit has a high turnover of personnel, infrequent related training, loss of key personnel such as chief computer/computer, or unit-peculiar problems that degrade drill proficiency.

d. Recommended Training Support.

(1) Personnel and equipment. A

battery FDC section TOE and a battery FDC section crew are required to train this drill.

(2) **Time requirements.** It is estimated that the battery FDC section crew will require 2 hours of initial training and 30 minutes of sustainment training.

(3) **Training area requirements.** Each FDC section undergoing training will require a 50- by 50-meter area for emplacement of the section vehicle or for a classroom of sufficient size to accommodate the TOE equipment and the crew.

(4) **Standards.** The drill standards are based on the following assumptions:

(a) All TOE personnel and equipment are available and operational.

(b) All personnel are MOS-qualified.

(c) Unless otherwise specified in the conditions, no other competing actions are

ongoing, and weather conditions are favorable.

e. Training Procedures. To train this drill, the chief computer will have his FDC crew occupy the training area.

(1) After the training area has been occupied, the chief computer will provide the XO's report and known battery, weapon, and map data. The unit tactical mission and the current met message are available. This task should be completed when occupation of the position is completed. Chart/BCS verification and application of multiplot GFT settings should be done without delay.

(2) The chief computer evaluates the actions of the section and notes all training deficiencies and omissions. An after-action review is given to the FDC section after completion of the drill. The drill is trained until no deficiencies are noted by the chief computer.

Table G-4. Initialize BCS for operation drill.

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Chief Computer Issue order to initialize the BCS. Perform chart checks, and derive multiplot GFT setting. Verify the initialization procedures.	You will be given an operational BCS and an adequate power source. Information required for initialization is available. Charts and graphical equipment are available. Fire direction center personnel have completed initialization.	Initialize BCS for operation. Perform a chart check. Derive multiplot GFT settings and apply to graphical equipment. Announce the order to the section. Recall selected initialization data/message, and spot-check for accuracy. Ensure that chart checks with the BCS are within standards (± 3 mils). Ensure that the derived GFT setting is properly applied to graphical equipment.
BCS Operator Apply power to BCU. Initialize BCS.	Use available power source. Information required for initialization is available. The BCU is properly cabled, and radios are on proper frequencies.	Operate from vehicle power/generator. Correctly complete and execute the following messages: BCS;INIT BCS;SWITCHES AFU;BAMOUNP BCS;MVD

Table G-4. Initialize BCS for operation drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
		BCS;SBT SPRT;MAP AFU;UPDATE BCS;PIECES FM;OBCO SPRT;GEOM MET;CM Perform chart check, and derive multiplot GFT settings.

*G-7. DETERMINE REPLOT DATA

a. General. This drill is an integral part of the battalion training system and was developed from the ARTEP and soldier's manuals. It trains ARTEP 6-100 subtask 3-I-6-1g. It applies to all FADAC/manual units.

b. Prerequisites. Certain crew drills, ARTEP tasks, and individual skills must be mastered before this drill can be trained. The pretraining requirements include the following:

- (1) ARTEP subtask: 3-I-6-3
- (2) Individual soldier's manual tasks:
 061-280-1005 061-280-2013
 061-280-1006 061-281-1001
 061-280-1100 061-281-1005
 061-280-2012
- (3) References:
 ARTEP 6-100
 FM 6-13E1/2/3
 FM 6-30

c. Practice. Following pretraining, the section must practice this drill to achieve initial proficiency. After initial proficiency has been achieved, sustainment training every 4 months is recommended. More frequent training may be necessary if the unit has a high turnover of personnel, infrequent related training, loss of key personnel such as chief computer/computer, or unit-peculiar problems that degrade drill proficiency.

d. Recommended Training Support.

(1) **Personnel and equipment.** A battery FDC section TOE and a battery FDC section crew are required to train this drill.

(2) **Time requirements.** It is estimated that the battery FDC section crew will require 2 hours of initial training and 30 minutes of sustainment training.

(3) **Training area requirements.** Each FDC section undergoing training will require a 50- by 50-meter area for emplacement of the section vehicle or for a classroom of sufficient size to accommodate the TOE equipment and the crew.

(4) **Standards.** The drill standards are based on the following assumptions:

- (a) All TOE personnel and equipment are available and operational.
- (b) All personnel are MOS-qualified.
- (c) Unless otherwise specified in the conditions, no other competing actions are ongoing, and weather conditions are favorable.

e. Training Procedures. To train this drill, the chief computer will have his FDC crew occupy the training area.

(1) After the training area has been occupied, the chief computer will provide the XO's report and known battery, weapon, and map data. The unit tactical mission and the current met message are available. This task should be completed when occupation of the position is completed. Chart/BCS verification and application of multiplot GFT settings should be done without delay.

(2) The chief computer evaluates the actions of the section and notes all training deficiencies and omissions. An after-action review is given to the FDC section after completion of the drill. The drill is trained until no deficiencies are noted by the chief computer.

Table G-5. Determine replot data drill.

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Chief Computer	The battery has fired a mission. The observer has requested RECORD AS TARGET , or the FDO has directed that replot be performed. Accurate target location is required to allow future use of the target.	Obtain refinement data from the observer. Determine replot grid and altitude. Report replot grid to the FIST.
Issue order to determine replot data.	Replot is required on a target that has been fired.	Direct and supervise the personnel during determination and use of replot data.
Verify the determination of replot data.	Replot is being conducted.	Ensure the personnel are determining replot data correctly.
Computer		
Determine and announce replot data (fuze quick or VT).	Replot is directed. Successive sites are determined by the VCO.	Determine and announce replot data without error within 90 seconds. Determine and announce initial replot range. Determine and announce replot deflection. Determine and announce final replot data. Record replot location.
Determine and announce replot data (fuze time).	Replot is directed.	Determine and announce all replot data without error within 3 minutes. Determine and announce the initial replot range. Determine and announce replot deflection. Determine site. Determine and announce final replot data. Record replot location.
FADAC Operator		
Replot targets with FADAC.	Replot is directed.	Determine initial firing data. Determine fire-for-effect data. Determine replot data. Record replot data.
HCO		
Replot targets and determine and announce grid location.	Replot is directed.	Replot targets without error within 8 minutes. Polar plot the location of the target from the battery center as directed. Determine and announce eight-digit grid coordinates of the polar plot location. Tick mark and label in black.
Compute and announce successive sites.	Site is requested.	Compute and announce site without error within 1 minute.

Table G-5. Determine replot data drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
RATELO Prepare and transmit replot location message to FIST.	Replot has been conducted.	Transmit replot location to FIST.

*G-8. DETERMINE AND APPLY MET CORRECTIONS

a. General. This drill is an integral part of the battalion training system and was developed from the ARTEP and soldier's manuals. It trains ARTEP 6-100 subtask 3-I-6-1e. It applies to all FADAC/manual units.

b. Prerequisites. Certain crew drills, ARTEP tasks, and individual skills must be mastered before this drill can be trained. The pretraining requirements include the following:

- (1) ARTEP subtask: 3-I-6-1
- (2) Individual soldier's manual tasks:
 - 061-280-1700 061-281-1001
 - 061-280-1701 061-281-1009
 - 061-280-1703 061-281-1702
 - 061-280-2205 061-282-2206
 - 061-280-2206 061-282-2700
 - 061-280-2702 061-282-2701
 - 061-280-2704
- (3) References:
 - ARTEP 6-100
 - FM 6-13E1/2/3

c. Practice. Following pretraining, the section must practice this drill to achieve initial proficiency. After initial proficiency has been achieved, sustainment training every 4 months is recommended. More frequent training may be necessary if the unit has a high turnover of personnel, infrequent related training, loss of key personnel such as chief computer/computer, or unit-peculiar problems that degrade drill proficiency.

d. Recommended Training Support.

(1) **Personnel and equipment.** A battery FDC section TOE and a battery FDC section crew are required to train this drill.

(2) **Time requirements.** It is estimated that the battery FDC section crew will require 6 hours of initial training and 2 hours of sustainment training.

(3) **Training area requirements.** Each FDC section undergoing training will require a 50- by 50-meter area for emplacement of the section vehicle or for a classroom of sufficient size to accommodate the TOE equipment and the crew.

(4) **Standards.** The drill standards are based on the following assumptions:

- (a) All TOE personnel and equipment are available and operational.
- (b) All personnel are MOS-qualified.
- (c) Unless otherwise specified in the conditions, no other competing actions are ongoing, and weather conditions are favorable.

e. Training Procedures. To train this drill, the chief computer will have his FDC crew occupy the training area.

(1) When information becomes available, the chief computer will order his section to derive met corrections and apply the corrections to graphical equipment.

(2) The chief computer evaluates the actions of the section and notes all training deficiencies and omissions. An after-action review is given to the FDC section after completion of the drill. The drill is trained until no deficiencies are noted by the chief computer.

Table G-6. Determine and apply met corrections drill.

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Determine met corrections.	A registration has been conducted. Total corrections and GFT settings have been determined. Ballistic and computer met messages current at the time of the registration are available. Position corrections are available from a prior registration. The tactical situation precludes firing another registration. Subsequent ballistic and computer met messages are received. The battery has not displaced. A firing capability along azimuths significantly different from unit's primary azimuth of fire is required.	Manual Determine position deflection correction, position velocity error, and position fuze correction. Time: 12 minutes. Time starts upon receipt of met message and registration data. Note. <i>FADAC/HHC/BCS residuals may require subsequent recomputation if they were initially computed by use of the last or standard met and a met is received later that was current at the time of the registration.</i>
		Manual/HHC Update GFT setting and GFT correction. Time: 11 minutes from receipt of met message to completion of GFT setting and deflection corrections. 11 minutes for HHC. FADAC/BCS Input new met data. Time: 5 minutes (manual) 1 minute (met tape—FADAC only) Manual Determine a valid GFT setting for each 800-mil segment of unit's area of responsibility by use of the eight-direction met technique within 45 minutes. FADAC Derive GFT settings for applicable octants. Note. <i>For RAP missions, apply propellant temperature range correction (manual, FADAC, and HHC).</i>
		Determine second and third multiplot GFT settings by use of the met to a met check gage point technique. Select met check gage points that are farthest (in range) from the registration point.
Chief Computer		
Order that position constants be determined.	All information necessary to compute the corrections is available.	Announce order to the section.

Table G-6. Determine and apply met corrections drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Spot-check data.	Fire direction center personnel have completed determining position constants.	Spot-check for the following: ◦ Use of proper TFT. ◦ Math errors. ◦ Use of proper met line. FADAC ◦ Entry of met message into FADAC. ◦ Input of proper adjusted data when determining residuals. ◦ Application of residuals to the FADAC and record of residuals in the FADAC logbook.
Order GFT settings be computed to selected octants.	Octants are identified, and met check gage point ranges are based on the tactical situation.	Announce order to the section.
Order firing data to be computed to a target outside the transfer limits of currently computed GFT settings.	A target is received outside transfer limits. Current met data and position constants/residuals are applied.	Announce order to the section.
Computer Determine position corrections.	A current met message and registration data are available.	Manual - Determine position deflection correction. - Determine position VE. - Determine position fuze correction.
Determine GFT setting for a 6,400-mil met.	Met data have been identified, and position constants are available.	Manual—shell HE, DPICM, RAP Determine multiplot GFT settings for required octants.
Update the GFT setting.	New met data have been identified.	Manual—shell HE, DPICM, RAP - Determine a new adjusted elevation for a multiplot GFT setting. - Determine a new adjusted time for a multiplot GFT setting. - Determine new total and GFT deflection corrections for a multiplot GFT setting. - Apply the multiplot GFT setting. - Determine the quadrant to fire. - Determine the time to fire. - Determine the deflection to fire.
Compute data to a target outside transfer limits.	Current met data and position constants are available. The fire order has been issued identifying charge, ammunition, and propellant lot. Chart data have been determined.	

Table G-6. Determine and apply met corrections drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
HCO (FADAC Operator)		
Determine residuals.	Current met data are applied to the FADAC.	Determine and apply FADAC residuals.
Derive a GFT setting for a 6,400-mil met.	Current met data and residuals are applied to the FADAC.	Determine multiplot GFT settings for shell HE, DPICM, and RAP.
Update the GFT setting.	New met data have been identified.	Input new met data. Derive multiplot GFT settings for shell HE, DPICM, and RAP.
Determine position corrections.	A current met message and registration data are available.	Determine position deflection correction. Determine position VE. Determine position fuze correction.
Determine a GFT setting for a 6,400-mil met.	Met data have been identified, and position constants are available.	Shell HE, DPICM, and RAP Determine multiplot GFT settings for required octants.
Update the GFT setting.	New met data have been identified.	Shell HE, DPICM, and RAP Determine multiplot GFT settings for required octants.

*G-9. ESTABLISH AND MAINTAIN COMMUNICATIONS

a. General. This drill is an integral part of the battalion training system and was developed from the ARTEP and soldier's manuals. It trains ARTEP 6-100 subtasks 3-I-6-1a and 3-I-6-6a. It applies to all units.

b. Prerequisites. Certain crew drills, ARTEP tasks, and individual skills must be mastered before this drill can be trained. The pretraining requirements include the following:

- (1) FM 6-50, chapter 10.
- (2) Individual soldier's manual tasks:

061-280-1006	113-587-3077
061-280-3000	113-596-1068
113-573-4003	113-600-1015
113-573-7017	113-622-1066
113-573-8006	113-622-2004
113-587-2043	113-622-2005

(3) References:

FM 6-30
FM 6-50
FM 21-2
FM 24-1
FM 24-18
STANAG 2867
TM 11-5820-401-10-1
TM 11-5820-401-10-2
TM 11-5820-477-12
TM 11-5830-340-12
TM 11-5985-357-13
TM 38-750

c. Practice. Following pretraining, the section must practice this drill to achieve initial proficiency. After initial proficiency has been achieved, sustainment training every 4 months is recommended. More frequent training may be necessary if the unit has a high turnover of personnel, infrequent related training, loss of key personnel such as chief computer/computer, or unit-peculiar problems that degrade drill proficiency.

d. Recommended Training Support.

(1) **Personnel and equipment.** A battery FDC section TOE and a battery FDC section crew are required to train this drill.

(2) **Time requirements.** It is estimated that the battery FDC section crew will require 2 hours of initial training and 30 minutes of sustainment training.

(3) **Training area requirements.** Each FDC section undergoing training will require a 50- by 50-meter area for emplacement of the section vehicle or for a classroom of sufficient size to accommodate the TOE equipment and the crew.

(4) **Standards.** The drill standards are based on the following assumptions:

(a) All TOE personnel and equipment are available and operational.

(b) All personnel are MOS-qualified.

(c) Unless otherwise specified in the conditions, no other competing actions are ongoing, and weather conditions are favorable.

e. Training Procedures. To train this drill, the chief computer will have his FDC crew occupy the training area.

(1) Immediately upon occupation of the training area, the chief computer will direct the section to establish radio and wire communications. To be proficient at this task, the section must be trained to maintain communications in all types of weather, on any terrain, and under electronic warfare conditions. This drill must be maintained continuously during all training and operational conditions. The chief computer will provide pertinent CEOI and operations order information. Time and drill sequence will begin when the section has occupied the position/training area. The maintenance phase of the drill will follow the establishment phase.

(2) The chief computer evaluates the actions of the section and notes all training deficiencies and omissions. An after-action review is given to the FDC section after completion of the drill. The drill is trained until no deficiencies are noted by the chief computer.

Table G-7. Establish and maintain communications drill.

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Chief Computer. Issue the order to establish and maintain communications.	The battery is conducting either middle- or high- intensity combat operations (simulated). The FDC section and equipment are in position.	Install FM radio set, and secure radio equipment to facilitate best transmission/reception. Use antenna group RC-292/OE-254 correctly. Use remote radio setting. Enter external radio nets as directed. Establish/maintain wire communications with the howitzer sections, battery operations center, and field storage location (if applicable). Direct the personnel during occupation of the position to establish and maintain FDC communications. Communications should be established with a high priority. Organize the section beforehand to ensure rapid and orderly occupation. Assign duties and ensure that tasks are understood. Assign section priorities for establishing the position.

Table G-7. Establish and maintain communications drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Verify the establishment and maintenance of communications.	The FDC section and equipment are in position. Communications are being established.	Ensure section members are thoroughly familiar with unit and section SOPs. Ensure the RATELO and other section members have the correct communications operating data. Ensure the FDC has entered all radio nets properly. Ensure the FDC has installed all communications equipment correctly. Ensure all required wire nets are operational.
Use FDC procedures to receive the firing battery and enemy transmissions.	The section is in a middle- or high-intensity combat environment (simulated).	Use procedures that hinder the capability of enemy targeting agencies in detecting and locating field artillery positions. Ensure that communications security procedures are rapidly followed by all radio or telephone operators operating in fire direction nets or FDC wire communications.
RATELO Prepare/operate FM radio sets. Install and operate a field telephone. Install radio set control group AN/GRA-39.	You have all required equipment and forms.	Install batteries in the AN/GRA-39. Install control units on site. Install field wire between the sites. Update DA Form 2404.
		Note. To dismount the set, reverse the procedures. Observe all applicable warnings.
Operate radio set control group AN/GRA-39.	You have properly installed the AN/GRA-39. You have an operational FM radio, another radio station with which to communicate, a CEOI extract, and an operator/attendant for the radio site.	Perform starting procedures. Conduct telephone communications check between local and remote control units. Conduct radio transmission and reception check. Conduct stopping procedures (when required).
		Note. Starting procedures and communications checks must be performed within 10 minutes.
Install antenna group OE-254/GRC.	You have an antenna group OE-254/GRC, a designated site for installation, two assistants, and a supervisor.	WARNING: If you must erect these long-range antennas near power lines, power-line poles, towers, or buildings with overhead power line connections, never put the antenna closer than twice the antenna height from the base of the power line, pole, tower, or buildings. Do not erect the antenna during a power storm.

Table G-7. Establish and maintain communications drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Operate intercommunications system AN/VIC-1 with FM radios (tracked vehicles only). Perform preventive maintenance checks and services (PMCS) on communications equipment. Use an automated CEOI. Prepare/submit operator's meaoning, intrusion, jamming, interference (MIJI) report. Prepare and transmit messages to observers. Encode and decode messages using KTC 600 tactical operations code (OPCODE).	You will have a vehicle with an AN/VIC-1 installed; FM radio sets mounted, connected, and operational; and a CEOI extract. You will be given all required equipment, materials, and forms. You are operating an FM radio within a net. An interfering signal of undesignated origin occurs. You have a CEOI extract, a pencil, paper, a compass or a map, and a watch or other time-determining source. You will be given an observer's call for fire, the fire order, and the fire order standards. You will be given a CEOI extract with KTC 600.	Evaluate the installation site. Lay out the installation site. Assemble the antenna. Erect the antenna. Connect the antenna. <i>Note. The antenna must be properly installed within 20 minutes.</i>
		Observe all warnings and cautions. Set intercom switches and controls. Connect audio accessories. Operate the radio intercom system Perform routine checks. Perform operator's daily PMCS. Perform operator's weekly PMCS (as necessary). Perform operator's monthly PMCS (as necessary). <i>Note. Perform all PMCS within 20 minutes (30 minutes if the installation includes an intercom system).</i>
		Submit the report to the net control station (NCS). Prepare the initial MIJI report. Submit the initial MIJI report. Assemble additional information for the follow-up MIJI report.
		Transmit the message to observer in sequence. Transmit angle T (if necessary). Transmit probable error in range (if necessary). Transmit time of flight (if necessary).
		Encode and decode a message within 30 seconds per code or word/phrase. Observe security precautions.

*G-10. PREPARE FOR DEDICATED BATTERY OPERATIONS

a. General. This drill is an integral part of the battalion training system and was developed from the ARTEP and soldier's manuals. It trains ARTEP 6-100 subtasks 3-I-6-1f and 3-I-6-6d. It applies to all 105-mm and 155-mm units.

b. Prerequisites. Certain crew drills, ARTEP tasks, and individual skills must be mastered before this drill can be trained. The pretraining requirements include the following:

- (1) ARTEP subtask: 3-I-6-1
- (2) Individual soldier's manual tasks:
061-280-1001
061-280-2019
- (3) References:
ARTEP 6-100
FM 6-13E1/2/3
FM 6-20

c. Practice. Following pretraining, the section must practice this drill to achieve initial proficiency. After initial proficiency has been achieved, sustainment training every 4 months is recommended. More frequent training may be necessary if the unit has a high turnover of personnel, infrequent related training, loss of key personnel such as chief computer/computer, or unit-peculiar problems that degrade drill proficiency.

d. Recommended Training Support.

(1) **Personnel and equipment.** A battery FDC section TOE and a battery FDC section crew are required to train this drill.

(2) **Time requirements.** It is estimated that the battery FDC section crew

will require 2 hours of initial training and 30 minutes of sustainment training.

(3) **Training area requirements.** Each FDC section undergoing training will require a 50- by 50-meter area for emplacement of the section vehicle or for a classroom of sufficient size to accommodate the TOE equipment and the crew.

(4) **Standards.** The drill standards are based on the following assumptions:

- (a) All TOE personnel and equipment are available and operational.
- (b) All personnel are MOS-qualified.
- (c) Unless otherwise specified in the conditions, no other competing actions are ongoing, and weather conditions are favorable.

e. Training Procedures. To train this drill, the chief computer will have his FDC crew occupy the training area.

(1) During normal operations in the area, the chief computer will inform the section that the battery will be dedicated to a company/team maneuver force in a movement to contact and that preparations to assume this role must be accomplished. To be proficient at this task, the section should be trained to react to *hasty transition to dedication* and *deliberate transition to dedication*. This drill should be accomplished during operations in an area and upon receipt of a properly authenticated order for dedication. The chief computer will provide the section crew.

(2) The chief computer evaluates the actions of the section and notes all training deficiencies and omissions. An after-action review is given to the FDC section after completion of the drill. The drill is trained until no deficiencies are noted by the chief computer.

Table G-8. Prepare for dedicated battery operations drill.

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
	The battery has been given a dedicated role to support a	Post maneuver force scheme of maneuver on situation map.

Table G-8. Prepare for dedicated battery operations drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Chief Computer Issue order to prepare for battery operations.	company/team in a movement to contact.	Plot control measures and checkpoints on the firing chart in blue. Receive the fire support plan.
		<i>Note. The deliberate fire support plan is received from battalion FDC/squadron fire support section. The hasty fire support plan is received by the battery FDC from the FIST (usually less than 5 minutes before dedication).</i>
		Obtain maneuver call signs and frequencies. Monitor maneuver company/team command net. Process planned targets. Plot and compute firing data for all planned targets and checkpoints. Send data for suppressive targets to howitzer section.
		<i>Note. Priority targets are assigned one per firing platoon.</i>
		Direct and supervise the personnel during preparation. Organize the section beforehand to ensure rapid and proper preparation. Assign duties and ensure that tasks are understood. Ensure section members are thoroughly familiar with unit and section SOPs.
HCO Plot control measures and checkpoints on firing charts. Plot targets and determine and announce chart data.	Fire support plan has been received.	Plot checkpoints in blue. Include planned targets and checkpoints. Mark grid north for each target checkpoint for use with the target grid. Input data in computer files.
VCO Post maneuver force scheme of maneuver on the situation map.	Fire support plan has been received.	Use the most current information. Update as new information is received.
Computer Process planned targets.	Fire support plan has been received.	Compute firing data for all planned targets and checkpoints. Send data for suppressive targets to howitzer sections, one priority target per firing platoon. Update firing data as required.

Table G-8. Prepare for dedicated battery operations drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
RATELO Obtain maneuver call signs and frequencies.	Fire support plan has been received.	Monitor maneuver company/team command net.

*G-11. MANAGE AND APPLY MUZZLE VELOCITY INFORMATION

a. General. This drill is an integral part of the battalion training system and was developed from the ARTEP and soldier's manuals. It trains ARTEP 6-100 subtasks 3-I-6-1 and 3-I-6-6. It applies to all units.

b. Prerequisites. Certain crew drills, ARTEP tasks, and individual skills must be mastered before this drill can be trained. The pretraining requirements include the following:

- (1) Individual soldier's manual task:
061-380-3910
- (2) References:
FM 6-1
FM 6-50
TM 11-7440-240-10
TM 11-7440-283-12-1
MCTV-90-1

c. Practice. Following pretraining, the section must practice this drill to achieve initial proficiency. After initial proficiency has been achieved, sustainment training every 4 months is recommended. More frequent training may be necessary if the unit has a high turnover of personnel, infrequent related training, loss of key personnel such as chief computer/computer, or unit-peculiar problems that degrade drill proficiency.

d. Recommended Training Support.

(1) **Personnel and equipment.** A battery FDC section TOE and a battery FDC section crew are required to train this drill.

(2) **Time requirements.** It is estimated that the battery FDC section crew will require 2 hours of initial training and 30 minutes of sustainment training.

(3) **Training area requirements.** Each FDC section undergoing training will require a 50- by 50-meter area for emplacement of the section vehicle or for a classroom of sufficient size to accommodate the TOE equipment and the crew.

(4) **Standards.** The drill standards are based on the following assumptions:

- (a) All TOE personnel and equipment are available and operational.
- (b) All personnel are MOS-qualified.
- (c) Unless otherwise specified in the conditions, no other competing actions are ongoing, and weather conditions are favorable.

e. Training Procedures. To train this drill, the chief computer will have his FDC crew occupy the training area.

(1) The chief computer will provide the necessary blank forms and MV data. He will then direct the section to determine updated MVV data, record the data, and prepare a velocimeter rotation schedule for upcoming firing. The drill sequence will begin when directed. The section should be trained to update MVV data when a new lot of propellant is being fired and when a set of calibration data has been determined for the fire unit.

(2) The chief computer evaluates the actions of the section and notes all training deficiencies and omissions. An after-action review is given to the FDC section after completion of the drill. The drill is trained until no deficiencies are noted by the chief computer.

Table G-9. Manage and apply muzzle velocity information drill.

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Chief Computer Issue the order to determine updated MVV data for the unit and apply the information.	The battery has completed measuring a set of calibration data by use of the M90 velocimeter.	Determine and apply MVV data for all weapons in the unit. Record the data in the unit ballistic computer. Update the unit MV logbook. Schedule the rotation of the M90 velocimeter. This drill should be accomplished within 30 minutes of receipt of a complete set of M90 velocimeter measurements from the firing battery.
Determine MVV data.	The FDC section has just been directed by the FDO to update MVV data on the basis of a new set of M90 velocimeter measurements. You receive an M90 velocimeter record from the firing battery.	Direct and supervise the personnel during MVV update. MVV data should be updated and recorded as soon as possible. Organize the section beforehand to ensure rapid and accurate computation. Assign duties and ensure that tasks are understood. Ensure section members are thoroughly familiar with unit and section SOPs. Average the powder temperatures. Determine the usable rounds. Determine the MVV data. Record MVV data in the MV logbook. Direct MVV data be entered in ballistic computers or on manual met forms. Determine muzzle velocities. Announce muzzle velocities to the XO.

*G-12. INITIALIZE THE HAND-HELD CALCULATOR FOR OPERATION

a. General. This drill is an integral part of the battalion training system and was developed from the ARTEP and soldier's manuals. It trains ARTEP 6-100 subtask 3-I-6-1. It applies to all units.

b. Prerequisites. Certain crew drills, ARTEP tasks, and individual skills must be mastered before this drill can be trained. The

pretraining requirements include the following:

- (1) ARTEP subtask: 3-I-6-1
- (2) Individual soldier's manual tasks:
061-282-2000
061-282-2001
061-282-2006
- (3) References:
ARTEP 6-100
FM 6-13E1/2/3

c. Practice. Following pretraining, the section must practice this drill to achieve initial proficiency. After initial proficiency has been achieved, sustainment training every 4 months is recommended. More frequent training may be necessary if the unit has a high turnover of personnel, infrequent related training, loss of key personnel such as chief computer/computer, or unit-peculiar problems that degrade drill proficiency.

d. Recommended Training Support.

(1) **Personnel and equipment.** A battery FDC section TOE and a battery FDC section crew are required to train this drill.

(2) **Time requirements.** It is estimated that the battery FDC section crew will require 2 hours of initial training and 30 minutes of sustainment training.

(3) **Training area requirements.** Each FDC section undergoing training will require a 50- by 50-meter area for emplacement of the section vehicle or for a classroom of sufficient size to accommodate the TOE equipment and the crew.

(4) **Standards.** The drill standards are based on the following assumptions:

(a) All TOE personnel and equipment are available and operational.

(b) All personnel are MOS-qualified.

(c) Unless otherwise specified in the conditions, no other competing actions are ongoing, and weather conditions are favorable.

e. Training Procedures. To train this drill, the chief computer will have his FDC crew occupy the training area.

(1) After the training area has been occupied, the chief computer will provide the XO's report and known battery, weapon, and map data for a registration or a derived GFT setting.

(2) The chief computer evaluates that actions of the section and notes all training deficiencies and omissions. An after-action review is given to the FDC section after completion of the drill. The drill is trained until no deficiencies are noted by the chief computer.

Table G-10. Initialize the hand-held calculator for operation drill.

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Chief Computer	You will be given an operational HHC and an adequate power supply.	Initialize the HHC for operation. Perform a chart check, and check firing data to a target.
Issue order to initialize the HHC for operation.	Information required for initialization is available.	Recall selected initialization information, and spot check for accuracy.
Verify the initialization process.	Fire direction center personnel have completed initialization.	Ensure that the range (± 30 meters) and azimuth check with the chart within standards (± 3 mils). Ensure that firing data computed to a target with the HHC are compatible with the BCS.
HHC Operator		
Prepare the HHC for operation.	You have been given an operational HHC.	Perform steps to prepare for action. Perform program setup.

Table G-10. Initialize the hand-held calculator for operation drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Input known data.	You have been given an operational HHC.	Input battery data. Determine and apply residuals.

*G-13. INITIALIZE FADAC FOR OPERATION

a. General. This drill is an integral part of the battalion training system and was developed from the ARTEP and soldier's manuals. It trains ARTEP 6-100 subtask 3-I-6-1c. It applies to all FADAC 105-mm, 155-mm, and 203-mm units.

b. Prerequisites. Certain crew drills, ARTEP tasks, and individual skills must be mastered before this drill can be trained. The pretraining requirements include the following:

- (1) FM 6-50, chapter 6.
- (2) Individual soldier's manual tasks:
061-281-1000 061-281-1013
061-281-1001 061-281-1104
061-281-1012
- (3) References:
ARTEP 6-100
FM 6-13E1/2/3
TM 5-2805-203-14
TM 5-6115-271-14
TM 9-1220-221-10
TM 9-1220-221-10-1
TM 38-750

c. Practice. Following pretraining, the section must practice this drill to achieve initial proficiency. After initial proficiency has been achieved, sustainment training every 4 months is recommended. More frequent training may be necessary if the unit has a high turnover of personnel, infrequent related training, loss of key personnel such as chief computer/computer, or unit-peculiar problems that degrade drill proficiency.

d. Recommended Training Support.

(1) **Personnel and equipment.** A battery FDC section TOE and a battery FDC section crew are required to train this drill.

(2) **Time requirements.** It is estimated that the battery FDC section crew will require 2 hours of initial training and 30 minutes of sustainment training.

(3) **Training area requirements.** Each FDC section undergoing training will require a 50- by 50-meter area for emplacement of the section vehicle or for a classroom of sufficient size to accommodate the TOE equipment and the crew.

(4) **Standards.** The drill standards are based on the following assumptions:

- (a) All TOE personnel and equipment are available and operational.
- (b) All personnel are MOS-qualified.
- (c) Unless otherwise specified in the conditions, no other competing actions are ongoing, and weather conditions are favorable.

e. Training Procedures. To train this drill, the chief computer will have his FDC section crew occupy the training area.

(1) While the section is occupying the training area, the chief computer will provide the XO's report, the azimuth of fire, and the battery grid locations. The unit tactical mission is known. The chief computer will provide the HCO with known battery, weapon, and map data and a current met message. This task should be accomplished immediately upon occupation of the position. Chart/FADAC verification and application of multitplot GFT settings should be done without delay.

(2) The chief computer evaluates the actions of the section and notes all training deficiencies and omissions. An after-action

review is given to the FDC section after completion of the drill. The drill is trained until no deficiencies are noted by the chief computer.

Table G-11. Initialize FADAC for operation drill.

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Chief Computer Issue order to initialize FADAC for operation.	The FADAC is operational, and known battery, weapon, and map data have been received. A current computer met message is available.	Perform program tests, and set up and enter known data into FADAC.
		Note. <i>This task should be accomplished immediately upon occupation of the position and completion of chart verification. The computer/VCO should apply the multiplot GFT setting to the GFT/GFT fan.</i>
Verify the initialization of FADAC for operation.	The FDC section and equipment are in position.	Direct the personnel during occupation of the position to establish and maintain the FDC. Organize the section beforehand to ensure rapid and orderly occupation. Assign duties and ensure that tasks are understood. Assign section priorities for establishing the position. Ensure section members are thoroughly familiar with unit and section SOPs.
HCO (FADAC Operator) Operate a generator set (FADAC).	The FADAC is being initialized.	Ensure the HCO and other section members have the correct known data. Ensure program tests, and setup are performed correctly, and ensure known data are entered into FADAC. Ensure chart/FADAC checks are performed and that checks are within tolerance. Ensure the multiplot GFT setting is derived properly and is placed on the GFT/GFT fan.
	You have been given an operational FADAC and a generator.	Prepare the generator set for starting. Place the generator set under load, and make adjustments as necessary. Stop the generator engine (when required).
Prepare the FADAC for operation.	You have been given a FADAC, a FADAC table, a generator, and required power cables.	Start the generator set. Perform program tests 1 through 3. Set up each fire unit.

Table G-11. Initialize FADAC for operation drill (continued).

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Enter known data into FADAC.	You have set up the FADAC and have known data.	Enter known data without error within 10 minutes. Enter battery data. Enter weapon and ammunition data. Enter map/area data. Enter met message. Enter and store observers' locations. Enter and store target, known point, and registration point information.
Derive a multiplot GFT setting by use of FADAC.	You have prepared the FADAC for operation. You are given three met check gage points for a propelling charge.	Derive the multiplot GFT setting without error within 4 minutes.
Service the generator set (FADAC).	You have been given a generator set, required manuals and forms, and pencil and paper.	Perform PMCS on the generator set. Perform PMCS on the generator engine. Enter data on DA Form 2404.

*G-14. DETERMINE SPECIAL CORRECTIONS

a. General. This drill is an integral part of the battalion training system and was developed from the ARTEP and soldier's manuals. It trains ARTEP 6-100 subtask 3-I-6-3j. It applies to all FADAC/manual units.

b. Prerequisites. Certain crew drills, ARTEP tasks, and individual skills must be mastered before this drill can be trained. The pretraining requirements include the following:

- (1) Individual soldier's manual tasks:
061-280-2800
061-280-2801
- (2) References:
ARTEP 6-100
FM 6-13E1/2/3

c. Practice. Following pretraining, the section must practice this drill to achieve

initial proficiency. After initial proficiency has been achieved, sustainment training every 4 months is recommended. More frequent training may be necessary if the unit has a high turnover of personnel, infrequent related training, loss of key personnel such as chief computer/computer, or unit-peculiar problems that degrade drill proficiency.

d. Recommended Training Support.

(1) **Personnel and equipment.** A battery FDC section TOE and a battery FDC section crew are required to train this drill.

(2) **Time requirements.** It is estimated that the battery FDC section crew will require 2 hours of initial training and 30 minutes of sustainment training.

(3) **Training area requirements.** Each FDC section undergoing training will require a 50- by 50-meter area for emplacement of the section vehicle or for a classroom of sufficient size to accommodate the TOE equipment and the crew.

(4) **Standards.** The drill standards are based on the following assumptions:

(a) All TOE personnel and equipment are available and operational.

(b) All personnel are MOS-qualified.

(c) Unless otherwise specified in the conditions, no other competing actions are ongoing, and weather conditions are favorable.

e. Training Procedures. To train this drill, the chief computer will have his FDC

crew occupy the training area. After the training area has been occupied, the chief computer will provide the XO's report containing piece displacement and platoon MVV data. The chief computer evaluates the actions of the section and notes all training deficiencies and omissions. An after-action review is given to the FDC section after completion of the drill. The drill is trained until no deficiencies are noted by the chief computer.

Table G-12. Determine special corrections drill.

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
	Upon receipt and computation of a call for fire, the FDC applies special corrections (FFE mission) or hasty corrections (adjust fire mission) by use of deliberate or hasty special corrections to the fire-for-effect data.	The FDC will apply special or hasty corrections to the firing data.
Chief Computer		
Issue the order to apply deliberate special corrections to a fire-for-effect mission.	The FDC has received a fire-for-effect mission. The radius of the target is 100 meters or less.	Announce the order to the fire direction center.
Issue the order to apply hasty special corrections to an adjust fire mission.	The FDC has received an adjust fire mission. The radius of target is 100 meters or less.	Announce the order to the fire direction center.
Computer		
Determine deliberate special corrections, and announce them to each platoon.	You will be given a completed record of fire with initial firing data, a prepared M10/M17 plotting board, and MV data for each platoon.	Compute deflection, quadrant, and time correction values. Apply correction values to initial firing data to determine each platoon's firing data. Announce special corrections to each platoon.
Determine hasty special corrections, and announce them to each platoon.	You will be given a completed record of fire with initial firing data, fire-for-effect data, platoon displacement data, and MV data for each platoon.	Compute deflection, quadrant, and time correction values. Apply correction values to fire-for-effect data for each platoon. Announce special corrections to each platoon.

APPENDIX H

TARGET ANALYSIS AND MUNITIONS EFFECTS

H-1. PURPOSE

Battalion and battery FDOs are responsible for supervising all operations within the fire direction center. The first step in processing any fire mission received in the FDC is issuing the FDO's fire order. The fire order is based on the call for fire and the FDO's assessment of the target. The fire order specifies a method of attack that will place a desired effect on the target. This appendix discusses the decision procedures, publications, and equipment used by the FDO to analyze and attack a target properly.

H-2. TARGET ANALYSIS

a. Target analysis is the examination of a potential surface target to determine the most suitable attack weapon/ammunition and the most suitable method of attacking a target.

b. All targets should be analyzed as they are received in the FDC and fire planning action initiated. The analysis of a target is valid only for the level at which it was performed. For example, a battalion FDO might consider an automatic weapon an insignificant threat to the brigade mission. However, the same weapon may be of critical importance to the battery FDO of a dedicated battery supporting a maneuver platoon in contact.

c. The amount of time devoted to target analysis and the thoroughness of the analysis depends on the following:

- (1) Amount of target information.
- (2) Availability of weapons to attack the target.
- (3) Urgency of the engagement.

H-3. DETERMINING THE PRECEDENCE OF ATTACK

a. General. When an FDO receives a fire mission, he has the following options:

- (1) Attack the target immediately.
- (2) Defer attacking the target until an existing fire mission is complete.
- (3) Pass the fire mission to another fire direction center.
- (4) Cancel the mission. An FDO selects a particular precedence of attack after considering the following:
 - (a) Target characteristics.
 - (b) Target location.
 - (c) Terrain.
 - (d) Weather.
 - (e) Commander's criteria.

b. Target Characteristics.

(1) Targets encountered on the battlefield vary considerably in composition, degree of protection, shape, mobility, and recuperability. To simplify the comparison of effectiveness of particular weapons and rounds, targets have been divided into four categories (table H-1). Examples are listed in each category. Under certain conditions,

Table H-1. Categories of targets.

CATEGORY	EXAMPLE
Area (personnel)	Squad Platoon Battery Company
Small (personnel)	Observation post Small patrol Command post
Small (materiel) (point)	Tank Armored personnel carrier Bunker, machine gun
Area (materiel)	Armored formation Truck park Ammunition dump

some examples could be listed in more than one category. For example, a motorized rifle battalion could be both a first category and a fourth category target.

(2) For personnel targets in particular, the posture of the target is extremely important. Normally, target postures used for personnel targets are standing, prone, and in foxholes. For computation, it is assumed that the personnel are wearing helmets and that personnel in foxholes are in a crouching position. In describing a target's posture, consideration must be given to the protection afforded by the terrain. For example, an infantry platoon may be attacking in a standing posture. However, irregular terrain may provide protection equivalent to the prone position. Usually, personnel targets will seek a more protective posture during an engagement; for example, from a standing to a prone position. This change is called posture sequencing. Posture sequencing causes considerable degradation of effects as additional volleys are fired and is the reason for the continual emphasis on surprise or mass fires. For the purpose of analysis, personnel targets in the offense are considered to be one half standing and one half prone during the first volley of fire and all prone for subsequent volleys. In a defensive configuration, personnel targets are considered to be one half prone and one half in foxholes during the initial volley and all in foxholes for subsequent volleys.

(3) A target must be analyzed to determine its weak points. Where the target is most vulnerable and what fires will best exploit its weaknesses are influenced by the degree of damage desired. Often there is a tendency to overkill the target when less combat power would suffice. On the basis of the commander's criteria, the FDO must ascertain the degree of effects needed (destruction/neutralization/suppression) to support the tactical plan (fig H-1). The acceptable degree of damage is that level that yields a significant military advantage. For example, fire from a heavily protected machine gun emplacement may be silenced by obscuration through smoke and subsequent engagement by direct fire as opposed to the expenditure of an excessive number of HE rounds required for destruction.

c. Target Location. The proximity of the target to friendly troops and the accuracy of the target location must be weighed. The importance of certain targets that are not accurately located may justify the fire of several units to ensure coverage. Close-in direct support fire requirements may dictate the use of a specific caliber of weapon.

d. Terrain. The terrain in the target area has a direct effect on the vulnerability of the target. Rugged terrain affords considerable natural cover and makes target location difficult. Certain terrain provides complete protection from some angles of approach but not others, thus influencing the unit and munitions to be employed. The nature of the vegetation in the target area should be considered in the selection of ammunition.

e. Weather. Weather is of little consequence when evaluating a target to be attacked with high-explosive/quick. However, precipitation and wind are of particular importance in evaluating a target to be attacked with ICM, smoke, or FASCAM or when using illumination projectiles. Low clouds, thick fog, surface water, and rain degrade the effectiveness of VT fuze M513/M514.

f. Commander's Criteria. All phases of target analysis are conducted within constraints established by the commander. In determining the precedence for attacking a target, primary consideration should be given to the commander's target priorities. On the basis of ammunition constraints, a commander will also specify the type effects he desires to be attained against specific target categories. The three target effects categories are discussed below.

(1) *Suppression.* Suppression of a target limits the ability of enemy personnel to perform their mission. Firing HE/VT reduces the combat effectiveness of personnel and armored targets by creating apprehension or surprise and causing tanks to button up. Smoke is used to blind or confuse. The effect of suppressive fires usually lasts only so long as the fires are continued. This type fire is used against likely, suspect, or inaccurately located enemy firing units. It can be delivered by small delivery units or means and requires little ammunition.

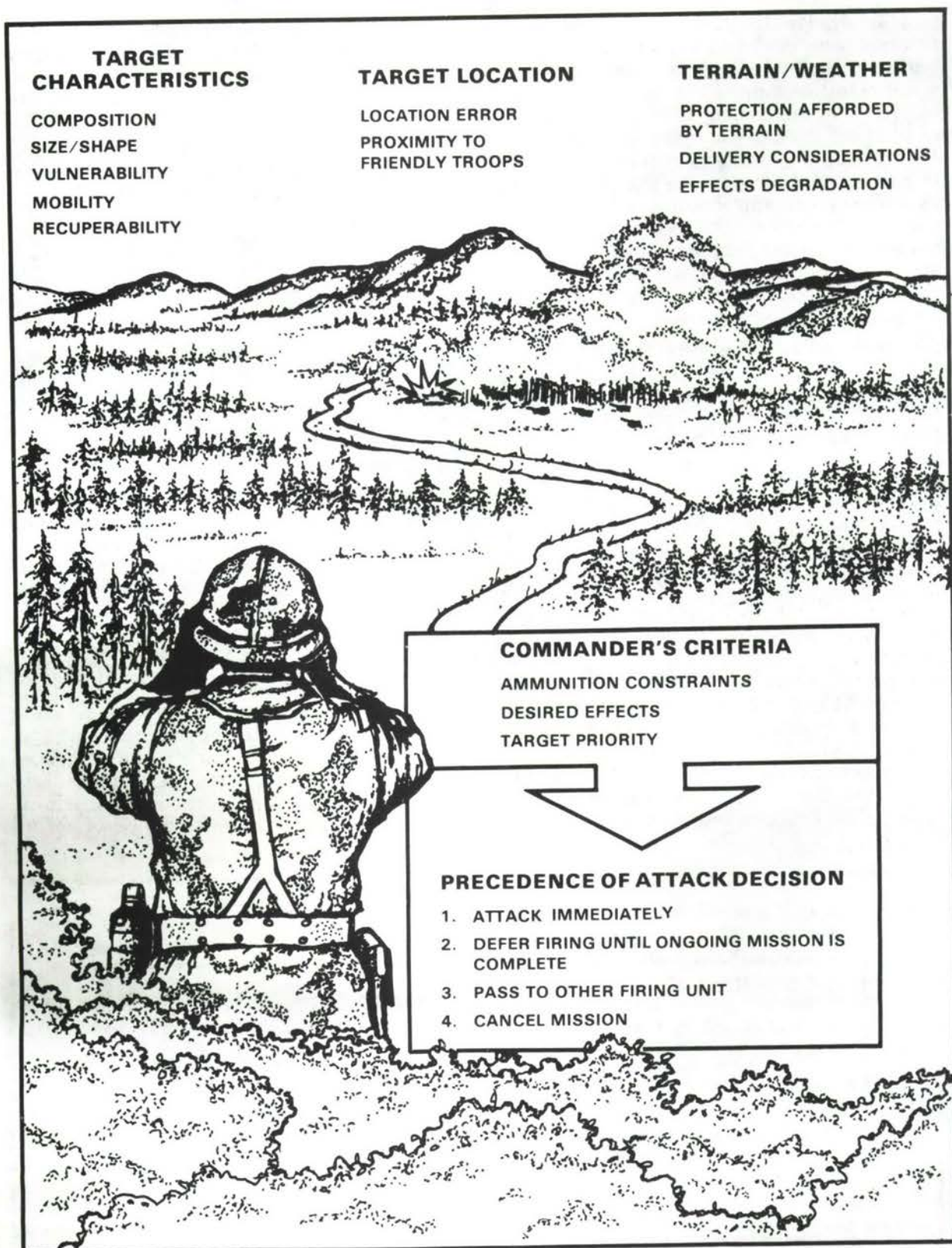


Figure H-1. Determining the precedence of attack.

(2) **Neutralization.** Neutralization of a target knocks the target out of the battle temporarily. Ten percent or more casualties will neutralize a unit. The unit will become effective again when the casualties are replaced and damage is repaired. Neutralization fires are delivered against targets located by accurate map inspection, by indirect fire adjustment, or by a target acquisition device. The assets required to neutralize a target vary according to the type and size of the target and the weapon/ammunition combination used.

(3) **Destruction.** Destruction puts the target out of action permanently. Thirty percent casualties or materiel damage inflicted during a short time span normally renders a unit permanently ineffective. Direct hits are required to destroy hard materiel targets. Targets must be located by accurate map inspection, by indirect fire adjustment, or by a target acquisition device. Destruction usually requires a large amount of ammunition from many units. Destruction of armored or dug-in targets with artillery weapons is not economical.

H-4. DETERMINING THE MOST SUITABLE AMMUNITION

When an FDO decides to attack a target, he must select a weapon/ammunition combination that can achieve a desired effect

with a minimum expenditure of available ammunition stocks. Figure H-2 depicts weapon/ammunition selection.

a. Munitions.

(1) **Ammunition type and quantity.** The nature of the target and its surroundings and the desired effects dictate the type and amount of ammunition to be used. For a detailed discussion of ammunition and fuzes, refer to FM 6-141-1 and FM 6-141-2. The ammunition resupply system may sometimes rule out the best ammunition selection. For example, extensive smoke fires may be needed to screen maneuver movement, but such fires would probably cause a resupply problem. Some types of fires require more ammunition than others. Suppression and neutralization fires usually use less ammunition than destruction fires.

(2) **Troop safety.** Troop safety is a major concern when considering the weapon/ammunition selection for firing close-in targets. The FDO must ensure that fires do not endanger troops, equipment, and facilities.

(3) **Residual effects in target area.** Residual effects from special ammunition will influence the occupation of an area, and FASCAM munitions may alter the direction of movement of supported elements. Conditions may be hazardous for supported troops occupying an area immediately following attack by certain munitions. Weather changes may alter choices of certain

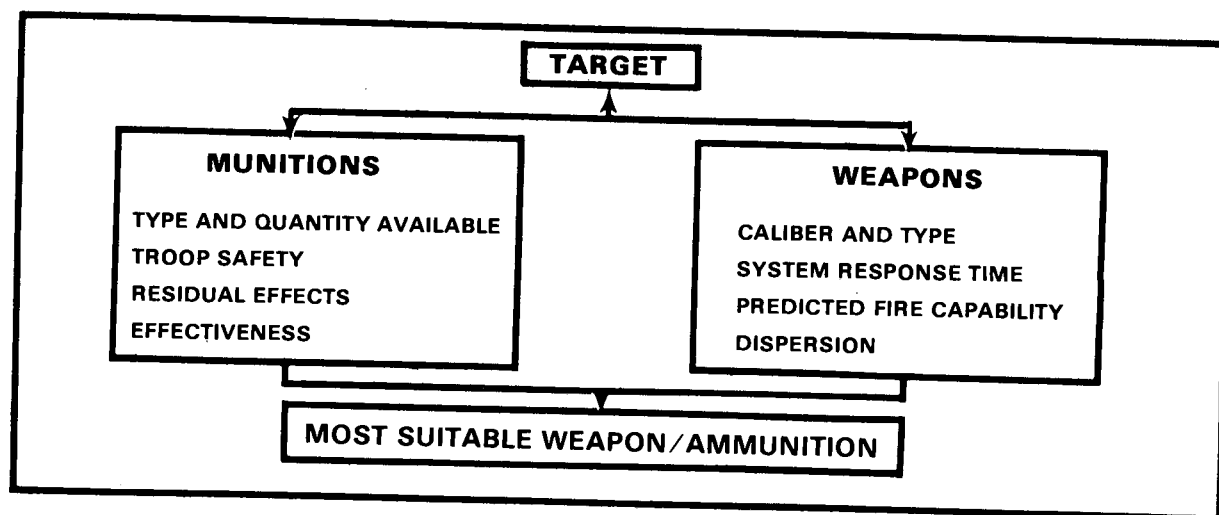


Figure H-2. Weapon/ammunition selection

a. Aiming Points. Normally, the size of the area to be attacked is determined by the size of the target or the size of the area in which the target is known to be located or suspected to be located. A single aiming point located on the center of the target is used to attack small targets. When attacking large targets, multiple aiming points must be designated to distribute the fires and insure adequate coverage. Chapter 13 gives procedures for establishing multiple aiming points.

b. Density and Duration of Fires. Intense fires of short duration generally produce the best target effect. However, the tactical situation may require fires to be continued over a long period of time. Some examples are harrassing and interdiction fires during darkness, screening smoke fires, continuous illumination fires, and suppressive fires supporting a maneuver final assault on an objective.

H-6. PREDICTING WEAPONS EFFECTS

The most important step in performing a target analysis is determining the number and type of rounds required to produce a desired effect on a target. The battalion or battery FDO determines attack data by referring to the appropriate JMEM, by using the GMET, or by relying on experience.

H-7. JOINT MUNITIONS EFFECTIVENESS MANUALS

Effectiveness tables published in joint munitions effectiveness manuals for surface-to-surface weapons (JMEM/SS) provide guidance for determining the expected fraction of casualties to personnel targets or damage to materiel targets. The JMEM/SSs are published as field manuals. The manuals currently available for all systems are listed in FM 6-141-1. The basic data for these manuals were obtained from test firings, actual combat performance, and mathematical modeling. Using JMEMs to determine attack data requires considerable

time. Because of time constraints, use of JMEMs at battalion and battery FDC levels is not recommended for engaging targets of opportunity. The effects data included in these manuals incorporate reliability, delivery accuracy, and munitions lethality against a representative spectrum of targets. The computational assumptions, defeat criteria, and instructions for use are included in each manual. Effects are listed for the following targets and conditions:

a. Personnel Targets. Target radii of 50, 100, 150, 200, and 250 meters for cannon systems. Data for standing, prone, and foxhole postures are listed.

b. Materiel Targets. A short description of the following targets and their vulnerabilities: 150-mm rocket and launcher, FROG-4 rocket and associated launcher, AAA fire control radar, 152-mm field gun/howitzer, T-55 medium tank (M109A1 manual only), and ZIL-157 truck (M109A1 manual only). Additional materiel targets are added to the JMEMs as data become available. Thus, manuals for some systems will include more targets than those for other systems.

c. Environment. Open terrain, marsh grass, and temperate forest.

d. Methods of Delivery. Observer adjusted and met + VE.

e. Battery Formations. Lazy W, star, and diamond.

f. Ammunition. High explosive, ICM, and chemical.

CAUTION: There is no assurance that the expected fraction of damage or casualties will be provided by any number of volleys in a given situation. Although not precisely within the mathematical definition, the method of averaging data used for the tables will result in less damage being realized for approximately 50 percent of the rounds and, conversely, greater damage for the other 50 percent of the rounds.

munitions (for example, smoke, illumination, and special ammunition). The incendiary effects of munitions may make areas untenable for supported forces. These effects can also deny the enemy use of selected terrain.

(4) **Effectiveness.** When properly delivered against appropriate targets, artillery fire support can be the decisive factor in a battle. The FDO must ensure that maximum effectiveness is attained from every mission fired. To match a munition to a target, the FDO must know what damage a munition can produce as well as the damage required to defeat a target. The lethality of a munition must be matched to the specific vulnerability of the target. Thus the FDO must understand the damage potential (blast, cratering, fragmentation, incendiary, and penetration) of specific munitions. Specific information regarding the effects of various munitions is found in the appropriate JMEM, FM 6-141-1, and FM 6-141-2. How to predict weapon effects will be discussed later in this appendix.

b. Weapons.

(1) **Caliber and type available.** In certain instances, an FDO may control the fires of reinforcing or general support reinforcing (GSR) units that are firing a different caliber. The FDO must have a thorough knowledge of the characteristics, capabilities, and vulnerabilities of each weapon system. Weapons that have slow

rates of fire and poor delivery accuracy are suited for long-range fires. Weapons that have rapid rates of fire and good delivery accuracy are suited for close fires.

(2) **System response time.** An FDO must ascertain the urgency of each fire mission received in his FDC. Small and medium weapons have a quicker firing response time than heavy weapons. Fire missions sent by the DS battalion to reinforcing or GSR units require more processing time than those sent directly to the DS units' own firing batteries.

(3) **Predicted fire capability.** The FDO must know the current survey, registration, and met status of all firing units under his control. The FFE missions should be assigned to units that have the best predicted fire capability.

H-5. DETERMINING THE METHOD OF ATTACK

The final step in the FDO's target analysis is the selection of a method of attack. The FDO must select a method of attack that ensures target area coverage and desired target effects. To determine the best method of attack, the FDO must consider aiming points, density, and duration of fires. Figure H-3 shows the method of attack selection considerations.

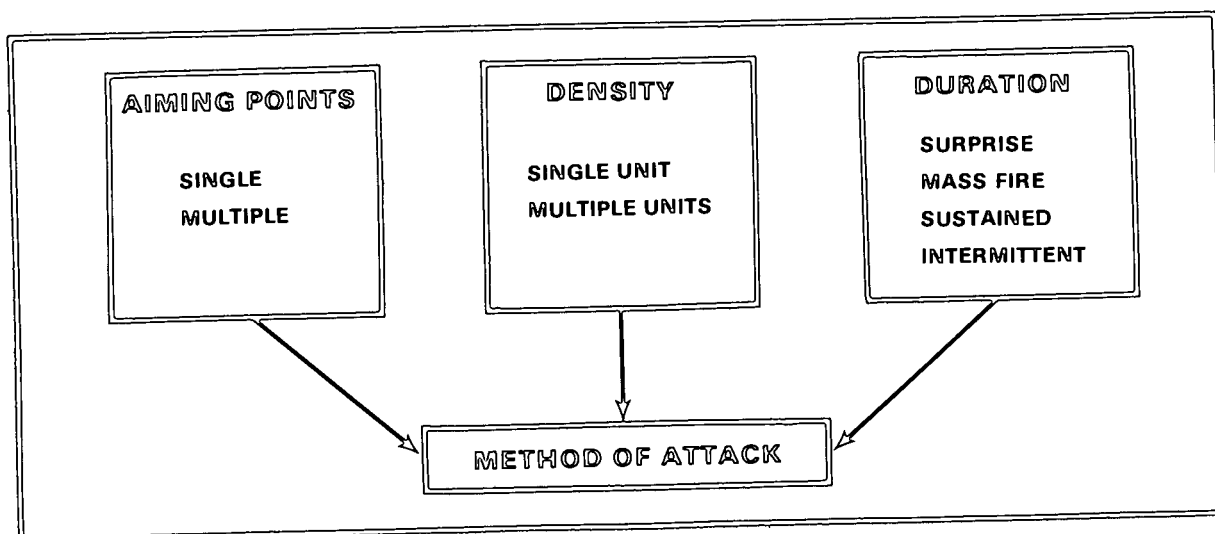


Figure H-3. Considerations in the selection of a method of attack.

(6) **Percentage of casualties.** The percentage of casualties (% CAS) is expressed as the average expected fraction of casualties. For example, if on one occasion, the fraction of casualties is 50 percent; on another occasion, 25 percent; and on a third occasion, 25 percent; the average expected fraction of casualties would be 33 percent. There is no probability or assurance associated with the percent of casualties. Against personnel targets in an offensive posture, the assumed desired average expected fractions of casualties are 30, 20, and 10 percent. For targets in a defensive posture, the assumed casualties are 10, 5, and 2 percent. The casualty percentages for the defense are lower than for the offense because of the greater shielding of targets in a defensive posture. Shown also is the average expected fraction of casualties for one battery and one battalion volley. The number of expected casualties is the product of the average expected fraction of casualties and the number of personnel in the target area.

(7) **Shell/fuze combinations.** The GMET contains effectiveness data for the standard HE shell (for example, M107 for 155-mm howitzer) with PD or proximity (VT) fuze and the antipersonnel improved conventional munitions.

(8) **Volleys required.** The GMET lists the number of battery or battalion volleys required to achieve a specified percentage of casualties against personnel for each size target, method of delivery, shell-fuze combination, and target location error. The letter P indicates that the number of volleys required is over 30 battery volleys or 10 battalion volleys and is considered prohibitive, because any additional volleys will not achieve a significant increase in casualties. The letter E indicates that the casualties obtained would be more than the specified casualty level.

(9) **Met + VE delivery technique.** Effects tables are based on the average weather change that could take place when using a 4-hour met message. Thus, when using met data that are older than 2 hours, more volleys will be required to achieve the desired fraction of casualties. Conversely, if more accurate data are being used, fewer volleys will be required.

(10) **Observer adjusted delivery techniques.** The tables are based on the assumption that the observer has conducted sufficient adjustment to place the center of the sheaf(s) on the adjusting point (target).

c. Other Considerations.

(1) **Volley versus time-on-target fires.** The GMET assumes that battery or battalion volley fire will be used. The greatest effects are achieved when surprise fires with maximum intensity are used. Normally, use of the TOT technique will reduce the GMET expenditure for a given situation because of the reduced time the enemy has to seek or increase his protection.

(2) **Materiel targets (area fire).** None of the weapons is considered effective against armored targets in area fire. The probability of obtaining a hit is remote. Undoubtedly, there will be bonus effects at times, but they should be considered only as bonus effects and should not be relied on. This is not to say that exposed personnel on or adjacent to materiel targets cannot be attacked successfully with artillery.

(3) **Round-off rule.** In some instances, the required expenditure for a required casualty level may appear excessive on the basis of one-volley effects. (See GMET Training Edition, Defensive Posture Side, MET + VE 250 TLE, 50 M RT.) The effects are calculated to four decimal places and rounded to two decimal places; thus, the one-volley effects of .02 may range from .0151 to .0250, and either one or two volleys may be required to achieve exactly .02 level of effects.

EXAMPLE:

Given:

- Unit:* 155 155-mm howitzer battalion.
- Target:* Platoon of infantry in the attack (assume offensive posture, radius of target 150 meters, target location error of 0 meters).
- Ammunition:* Sufficient conventional ammunition with VT fuze is available.
- Effects desired:* Minimum average expected fraction of casualties of 30 percent.
- Procedure:* Slide the cursor to MET + VE delivery technique 0 TLE on the offensive posture.

side of the GMET. Look under the window for 30 percent casualties to see that nine battalion volleys of VT-fuzed ammunition would be required to achieve 30 percent average expected fraction of casualties.

Solution:

The FDO orders the battalion to fire nine volleys VT fuzed ammunition to achieve 30 percent average expected fraction of casualties.

H-9. QUICK REFERENCE TABLES

a. If JMEMs or GMETs are not available, the FDO can use the guide for cannon attack of typical targets (table H-3). The table lists selected personnel and materiel targets and indicates the order of effectiveness of each shell/fuze combination. Targets not indicated should be equated to targets that are listed. The table can be used for all calibers. Use of the table is explained in the notes.

Table H-3. Guide for cannon attack of typical targets.

TARGET TYPE	OBSERVATION	WEAPON	PROJECTILE	HE FUZE	RESULTS DESIRED	REMARKS
PERSONNEL In open or in foxhole without overhead cover	Observed/ unobserved	All	HE	Proximity (VT), time	Destruction	Massing is required. ¹ TOT missions are most effective. First volley is most effective.
		All	HE	Proximity (VT), time	Neutralization	Massing is required except for small targets.
		All	HE	Quick, proximity, time	Suppression	Response time is critical against active targets. Preferred fuze is proximity.
		All	APICM	NA	Destruction	Massing is required on large targets. TOT missions are most effective.
		All	APICM		Neutralization	Cannon battery volleys are sufficient.
	Observed	All	HE	Quick/delay (ricochet)	Neutralization	Massing is required. TOT missions are most effective. Consider use of WP to drive personnel out of foxholes.
		All	HE	Proximity, time, delay, quick	Suppression	Response time is critical against active targets. Proximity fuze is preferred. Consider use of smoke for obscuration.
		All	APICM	NA	Neutralization	Massing is required. TOT missions are most effective.
		All	APICM	NA	Suppression	Consider use of ICM on intermittent basis for increased effectiveness.
	Observed	All (preferably 155 mm or larger)	HE	Delay, quick	Destruction	Use direct fire or assault techniques. Fire HE quick at intervals to clear away camouflage, earth cover, and rubble.

Table H-3. Guide for cannon attack of typical targets (continued).

TARGET TYPE	OBSERVATION	WEAPON	PROJECTILE	HE FUZE	RESULTS DESIRED	REMARKS
Attacking battery position	Observed	105 mm All	Beehive HE APICM	Time	Destruction	Set fuze to detonate on the ascending branch of the trajectory for close-in defense of battery area.
VEHICLE ² Tanks	Observed	All	HE	Proximity, time	Suppression	Fire projectile HE to force tanks to button up and personnel outside to take cover or disperse. WP may blind vehicle drivers, and fires may be started from incendiary effect on outside fuel tanks. WP or fires may obscure adjustment. DPICM is preferred munition for unobserved fire.
	Observed/ unobserved	155 mm	DPICM	NA	Suppression	See paragraph 7-7, FM 6-141-2. Massing is effective; ICM is preferred.
		203 mm	DPICM	NA	Suppression	See FM 6-141-2. Massing is effective; ICM is preferred.
	Observed	155 mm	FASCAM	NA	NA	Both antitank and anti-personnel projectiles should be used.
	Observed Direct fire	155 mm	Copperhead	NA	Destruction	
		105 mm	HEP, HEP-T HEAT	NA	Destruction	
Armored personnel carriers	Observed	All	HE	Proximity, time	Suppression	Force vehicles to button up and personnel outside to take cover or disperse.
	Observed/ unobserved	155 mm	APICM DPICM	NA	Neutralization	See FM 6-141-2. Massing is effective.
		203 mm	APICM DPICM	NA	Neutralization	See FM 6-141-2. Massing is effective.
		155 mm	FASCAM	NA	NA	See remarks for tanks.
	Observed	155 mm	Copperhead	NA	Destruction	
Trucks	Observed/ unobserved	All	HE	Proximity, time	Destruction	ICM is preferred munition.
		155 mm	DPICM	NA	Destruction	
		203 mm	DPICM	NA	Destruction	

Table H-3. Guide for cannon attack of typical targets (continued).

TARGET TYPE	OBSERVATION	WEAPON	PROJECTILE	HE FUZE	RESULTS DESIRED	REMARKS
WEAPONS						
Antitank missile	Observed	All	HE	Quick	Suppression	Response time is critical. Intermittent fire may be required. Change to fuze proximity or DPICM for materiel damage if anti-tank guided missile platform on BRDM is raised.
Air defense						
ZSU-23-4	Observed/ unobserved	All	HE	Proximity	Firepower kill	Smoke may also be used to obscure gunner's line of sight to friendly aircraft. ICM is preferred munition. Consider converged sheaf if weapon is point target and accurately located.
SA 6		155 mm	DPICM		Firepower kill	
		203 mm	DPICM	NA	Firepower kill	
SA 8, 9	Observed	All	HE	Quick	Suppression	Response time is critical. Intermittent fire may be required.
		All	HE	Quick	Firepower kill	Same as above.
Towed FA mortars multiple rocket launcher	Unobserved	All	HE, WP	Proximity, time	Firepower kill	WP is used to ignite materiel. See personnel targets for results desired.
		All	APICM	NA		See personnel targets section for results desired. TOT missions are most effective. Massing is usually required.
		155 mm	FASCAM	NA	NA	Use ADAM projectile in conjunction with HE or ICM for sustained effects.
Self-propelled FA battery	Unobserved	All	HE, WP	Proximity, time	Suppression	WP is used to ignite materiel.
		All (less 105 mm)	DPICM	NA	Suppression	ICM is preferred munition.
		155 mm	FASCAM	NA	NA	Use ADAM projectile in conjunction with HE or ICM for sustained effects.

Table H-3. Guide for cannon attack of typical targets (continued).

TARGET TYPE	OBSERVATION	WEAPON	PROJECTILE	HE FUZE	RESULTS DESIRED	REMARKS
Surface-to-surface missile	Unobserved	All (less 105 mm)	HE	Proximity, time	Firepower kill	Use converged sheaf if time and target location accuracy permit. TLE in excess of 200 meters requires massing of fires. ICM is preferred munition.
		All (less 105 mm)	DPICM DPICM	NA	Firepower kill	Same as above.
MISCELLANEOUS Radar	Unobserved	All	HE	Quick, time proximity	Firepower kill	Use converged sheaf if time and target location accuracy permit. TLE in excess of 200 meters requires massing of fires. ICM is preferred munition.
		155 mm 203 mm	DPICM DPICM	NA	Firepower kill	Same as above.
Artillery command and observation posts	Observed	All	HE	Quick	Suppression	Intermittent fire may be required. HE is preferred munition when response time is critical.
		155 mm 203 mm	DPICM DPICM	NA	Suppression	
Command post	Unobserved	All	HE	Proximity, time	Neutralization or destruction	Use ADAM for sustained effects. When target contains personnel and light materiel targets, DPICM is preferred munition.
		155 mm 203 mm	DPICM DPICM	NA	NA	See above.
Supply installation	Unobserved	All	HE, WP	Quick	Fires	Large target location errors require massing to ensure target coverage.
Boats	Observed	All	HE	Time	Suppression	Attack as moving personnel target.

Table H-3. Guide for cannon attack of typical targets (continued).

TARGET TYPE	OBSERVATION	WEAPON	PROJECTILE	HE FUZE	RESULTS DESIRED	REMARKS
Bridges	Observed/ unobserved	All (preferably 155 mm or larger)	HE	Quick, CP, delay	Destruction	Direction of fire is preferably with long axis of bridge. Destruction of permanent bridges is best accomplished by knocking out bridge support. Fuze quick is used for wooden or pontoon bridges.
	Observed	155 mm	Copperhead	NA	Destruction	
Fortifications	Observed	All (preferably 155 mm or larger)	HE	CP, delay, quick	Destruction	Use highest practical charge in assault and direct fire.
		155 mm	Copperhead	NA	Destruction	
¹ Targets, regardless of type, with an estimated target radius of greater than 150 meters usually require massing for effective attack. ² The first objective of firing on moving vehicles is to stop the movement. For this purpose, a deep bracket is established so that the target will not move out of the initial bracket during adjustment. Speed of adjustment is essential. If possible, the column should be stopped at a point where vehicles cannot change their route and where one stalled vehicle will cause others to stop. Vehicles moving on a road can be attacked by adjusting on a point on the road and then timing the rounds fired so that they arrive at that point when a vehicle is passing it. A firing unit or units, if available, may fire at different points on the road simultaneously.						

b. The expected area of coverage table (table H-4) can be used to determine the appropriate size of a battery one volley or battalion one volley of both HE and ICM for the various caliber weapon systems. The

FDO can use table H-4 to determine the size target that can be attacked by use of battery or battalion volleys. The density of coverage is not considered, but the density of coverage of ICM is much greater than that of HE.

Table H-4. Expected area of coverage (meters).

MUNITIONS	105 mm	155 mm	203 mm
ICM (AP)	BTRY ① BN ①	BTRY ① BN ①	BTRY ① BN ①
Square	250 × 250 380 × 380	266 × 266 390 × 390	239 × 239 320 × 320
Circle (Radius)	140 215	150 220	135 180
HE	BTRY ① BN ①	BTRY ① BN ①	BTRY ① BN ①
Square	248 × 248 380 × 380	275 × 275 390 × 390	239 × 239 319 × 319
Circle (Radius)	140 215	155 220	135 180

c. The expected fraction of casualties/personnel table (table H-5) can be used to determine the optimum method of attacking a personnel target of 50 meters radius to achieve the commander's criteria. Table H-5 cannot be used for materiel targets.

Table H-5. Expected fraction of casualties/personnel.

PROJECTILE	IF TARGET RADIUS 50 = METERS, THEN:			
		ICM (AP)	HE/VT	HE/PD
105 mm	BTRY 1	07	07	04
	BN 1	20	20	12
155 mm	BTRY 1	15	05	03
	BN 1	35	16	11
203 mm	BTRY 1	15	03	02
	BN 1	38	10	05

APPENDIX I

SAMPLE PROBLEM KNOWN DATA

I-1. KNOWN DATA

The known data in tables I-1 through I-8 are used for all sample problems throughout this publication unless otherwise noted.

a. The map used for all sample problems is the Lawton, Series V783, Sheet 6353 III, 1:50,000 map.

b. The azimuth of lay for all batteries is 6,350 mils.

c. The MVVs (table I-6) are for all types of ammunition unless otherwise noted. The values are the averages of the weapon MVVs.

d. The target numbering blocks authorized are FDC: AC7800 to AC7850 and FIST: AA7050 to AA7199.

Table I-1. Battery locations.

BATTERY ¹	GRID COORDINATES		ALTITUDE (METERS)
A	61321	32489	335
B	60858	32640	352
C	60478	32859	348

¹All batteries are 155-mm M109A3 howitzer batteries except where otherwise noted for instructional purposes.

Table I-2. Observer locations.

OBSERVER	GRID COORDINATES		ALTITUDE (METERS)
O1	59748	33872	370
O2	62213	34190	391
Radar	61550	32572	358

Table I-3. Targets that are known points.

TARGET	GRID COORDINATES		ALTITUDE (METERS)
AA7056	6155	3670	389
AA7059	6258	3835	363
AA7052	5950	3706	350
AA7054	6234	3826	390
AA7050	6068	3644	363
Reg Pt 1	60553	37465	377
Reg Pt 2	63341	37425	376

Table I-4. Piece locations for Battery A (from geographical battery center).

GUN	LOCATION (RIGHT/LEFT)	LOCATION (FORWARD/BACK)
1	R230	F250
2	R10	F220
3	R60	F25
4	L130	B20
5	L35	B240
6	L270	B295

Table I-5. Platoon center locations for battery A.

PLATOON	GRID COORDINATES		ALTITUDE (METERS)
Right	61441	32624	355
Center	61291	32491	355
Left	61171	32224	355

Table I-6. Muzzle velocity variations.

PLATOON	MUZZLE VELOCITY VARIATION
Right	+1.0 m/s
Center	0
Left	-0.8 m/s

Table I-7. Lot designations.

PROJECTILES	LOT	PROPELLANTS	LOT
HE	X	GB	Y
ADAM-S	B	GB (ODD LOT)	O
ADAM-L	C	M206	J
DPICM	I	M80 (203-mm example)	C
RAAMS-S	E	WB	P
RAAMS-L	D	M119A1	R
HE-RAP	M	M207	G
NUC-RAP	Q	M188 (203-mm example)	A
HC	H		
WP (M825)	W		
WP	Z		
CHEMICAL (GB)	G		
CHEMICAL (VX)	V		
ILLUMINATION	L		
NUCLEAR	N		

Table I-8. Call signs.¹

AGENCY	CALL SIGNS
FIST	B6H23
Battery A FDC	T2G12
Battery B FDC	T2J27
Battery C FDC	T2V54
Battalion FDC	Z4E76

¹Digital addresses are not used in the examples.

I-2. MULTILOT GFT SETTING

The following multiplot GFT setting is used in the examples unless otherwise noted:

GFT A: Chg 4, Lot XY, Rg 3730, El 225, Ti 12.8

GFT A: Chg 4, Lot XY, Rg 5140, El 335, Ti 18.9

GFT A: Chg 4, Lot XY, Rg 5580, El 374, Ti 21.0

Average total deflection correction: L2

Average GFT deflection correction: R4

Note. For all problems and examples, use TFT 155-AM-2 and associated graphical equipment when possible.

I-3. STANDING OPERATING PROCEDURES

The following is a summary of the unit SOPs that apply to the examples in this publication.

a. Normally, the unit fires one round, shell HE, fuze quick in adjustment. The odd lot powder will be used in adjustment before the main lot (registered) that is to be used for fire-for-effect missions.

b. In fire-for-effect missions, shell DPICM is fired, and the registered powder lot from the DPICM self-registering mode registration is used.

c. In the interest of speed and accuracy, the unit uses the hasty correction tables in appendix A in adjustment and fire-for-effect missions. Platoon locations, plotted on the firing chart, are used in immediate-type missions instead of the hasty correction tables.

Note. Most fire mission examples in this publication do not have a gun located over the geographical battery center; this was done to show the technique of applying special corrections.

d. Immediate suppression missions are fired with a platoon two rounds, shell HE, fuze VT. Immediate smoke missions are fired with a platoon two rounds. The left gun fires shell HC, fuze time, and the right gun fires shell WP, fuze quick.

e. The computer selects and assigns the next unassigned target number to each mission.

APPENDIX J

NEW DEPARTMENT OF THE ARMY FORMS

The new DA forms shown in figures J-1 through J-6 are for use in field artillery cannon gunnery procedures. DA Form 5336-R, DA Form 5337-R, DA Form 5338-R, DA Form 4982-R, and DA Form 4982-1-R are reproducible.

203-MM NUCLEAR COMPUTATION WORK SHEET
FOR M753 ROCKET-ASSISTED PROJECTILE

(Use with firing table 8-5-1.)
For use of this form, see FM 6-40; proponent agency is TRADOC.

DATE-TIME GROUP		BATTERY	PIECE NUMBER	TARGET	CHARGE
K-TRANSFER					
STEP	PROCEDURE	VALUE	STEP	PROCEDURE	VALUE
1	ALTITUDE OF TARGET (1 METER)		21	HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE ROCKET MOTOR TEMPERATURE RANGE CORRECTION (TABLE E.1) (1 METER)	
2	HEIGHT OF BURST ABOVE TARGET (1 METER)				
3	ALTITUDE OF BURST (1 + 2) (1 METER)		22	DIFFERENCE (20 - 21) (1 METER)	
4	ALTITUDE OF BATTERY (1 METER)		23	CORRECTED RANGE (6 + 13 + 19 + 22) (10 METERS)	
5	HEIGHT OF BURST ABOVE GUN (3 - 4) (1 METER)				
6	CHART RANGE TO TARGET (10 METERS)		24	ELEVATION ~ 23 (HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE GFT SETTING) (1 MIL)	
7	COMPLEMENTARY RANGE (TABLE B) (1 METER)		25	SITE (GFT, VERTICAL INTERVAL ~ 5 AT RANGE 6) (1 MIL)	
8	ENTRY RANGE (6 + 7) (1 METER) (100 METERS)		26	QUADRANT ELEVATION FOR HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE (24 + 25) (1 MIL)	
9	Δ MUZZLE VELOCITY (TABLE E) (NUCLEAR PROJECTILE POWDER TEMPERATURE [°F]) (0.1 METER PER SECOND)		27	ANGLE OF SITE (GST, C- AND D-SCALES) (1 MIL)	
			28	ELEVATION + COMPLEMENTARY ANGLE OF SITE (26 - 27) (1 MIL)	
10	Δ MUZZLE VELOCITY (TABLE E) (HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE POWDER TEMPERATURE [°F]) (0.1 METER PER SECOND)		29	FUZE SETTING ~ 28 (HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE GFT SETTING) (0.1)	
			30	BALLISTIC FUZE CORRECTION FOR NUCLEAR PROJECTILE (PART 2, TABLE B) (0.1)	
11	DIFFERENCE (9 - 10) (0.1) DECREASE/INCREASE		31	FUZE SETTING TO FIRE (29 + 30) (0.1)	
12	UNIT CORRECTION (TABLE F, COLUMN 10/11) (0.1)		32	CHART DEFLECTION TO TARGET (1 MIL)	
13	CORRECTION FOR PROPELLANT CHARGE TEMPERATURE (11 × 12) (1 METER)		33	DEFLECTION CORRECTION (GFT DEFLECTION CORRECTION + DRIFT ~ ELEVATION 24) (1 MIL)	
14	NUCLEAR PROJECTILE WEIGHT (0.1 POUND)				
15	HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE WEIGHT () (PAGE VI, TFT) (0.1 POUND)		34	BALLISTIC DEFLECTION CORRECTION (PART 2, TABLE A) (0.1 MIL) (1 MIL)	
16	DIFFERENCE (14 - 15) (0.1 POUND) DECREASE/INCREASE				
17	DIFFERENCE IN SQUARE WEIGHT (16 ÷ 2.5) (0.1) DECREASE/INCREASE		35	DEFLECTION TO FIRE (32 + 33 + 34) (1 MIL)	
18	UNIT CORRECTION (TABLE F, COLUMN 18/19) (1 METER)		36	QUADRANT ELEVATION FOR HIGH-EXPLOSIVE/ROCKET-ASSISTED PROJECTILE 26 (1 MIL)	
19	CORRECTION FOR PROJECTILE WEIGHT (17 × 18) (1 METER)				
20	NUCLEAR PROJECTILE ROCKET MOTOR TEMPERATURE RANGE CORRECTION (TABLE E.1) (1 METER)		37	BALLISTIC CORRECTION FOR NUCLEAR PROJECTILE (PART 2, TABLE A) (1 MIL)	
			38	QUADRANT ELEVATION TO FIRE (36 + 37) (1 MIL)	

203-MM NUCLEAR COMPUTATION WORK SHEET FOR M422A1

For use of this form, see FM 6-40; proponent agency is TRADOC.

STEP	ENTER						
1	M106 GFT SETTING	CHARGE	LOT	RANGE	ELEVATION	TIME	GFT DEFLECTION CORRECTION

KNOWN DATA				
2	BATTERY ALTITUDE	TARGET ALTITUDE	CHART RANGE	DATE
	PROPELLANT TEMPERATURE	HIGH-EXPLOSIVE PROJECTILE WEIGHT	NUCLEAR PROJECTILE WEIGHT	TIME

ENTER THE INTRODUCTION TO FT 8-ADD-H-1 FOR CORRESPONDING CHARGE FROM 1 ABOVE _____

STEP	PROCEDURE	VALUE
3	RANGE CORRECTION FOR PROPELLANT TEMPERATURE (FT 8-ADD-H-1, TABLE C).	
4	RANGE CORRECTION FOR PROJECTILE WEIGHT DIFFERENCE (FT 8-Q-1, TABLE F).	
5	$[3] + [4] + \text{CHART RANGE} = \text{CORRECTED RANGE}.$	
6	ADD TARGET ALTITUDE AND HEIGHT OF BURST.	
7	SUBTRACT BATTERY ALTITUDE FROM STEP $[6]$ = VERTICAL INTERVAL.	
8	DETERMINE SITE CORRESPONDING TO STEP $[7]$ (GST).	
9	IF VERTICAL INTERVAL IS GREATER THAN OR EQUAL TO 100, USE C- AND D-SCALES TO DETERMINE ANGLE OF SITE; IF VERTICAL INTERVAL IS LESS THAN 100, GO TO STEP $[11]$.	
10	SUBTRACT STEP $[9]$ FROM STEP $[8]$ = COMPLEMENTARY ANGLE OF SITE.	
11	DETERMINE ELEVATION ~ CORRECTED RANGE (STEP $[5]$).	
12	DETERMINE FUZE SETTING ~ ELEVATION + COMPLEMENTARY ANGLE OF SITE (STEP $[10]$).	
13	ADD STEPS $[8]$ AND $[11]$ = HIGH-EXPLOSIVE QUADRANT ELEVATION.	
14	ADD CHART DEFLECTION + DRIFT + GFT DEFLECTION CORRECTION = HE DEFLECTION. _____ + _____ + _____ =	
15	CORRECTIONS TO HIGH-EXPLOSIVE QUADRANT ELEVATION FOR SHELL NUCLEAR (FT 8-ADD-H-1, TABLE A).	
16	CORRECTIONS TO HIGH-EXPLOSIVE DEFLECTION FOR SHELL NUCLEAR (FT 8-ADD-H-1, TABLE A).	
17	CORRECTIONS TO HIGH-EXPLOSIVE FUZE FOR M591 FUZE (FT 8-ADD-H-1, TABLE B).	
18	ADD STEPS $[12]$ AND $[17]$ NUCLEAR TIME M591.	
19	ADD STEPS $[14]$ AND $[16]$ = NUCLEAR DEFLECTION.	
20	ADD STEPS $[13]$ AND $[15]$ = NUCLEAR QUADRANT ELEVATION.	

COMPUTER CHECKLIST

For use of this form, see FM 6-40; the proponent agency is TRADOC.

FIRE ORDER STANDARDS					ADJUST FIRE	FIRE FOR EFFECT	PIECE DISPLACEMENT DATA			
1. UNIT TO FIRE							GUN NUMBER	GRID	DISPLACEMENT	
2. ADJUSTING ELEMENT/METHOD OF FIRE OF ADJUSTING ELEMENT									LATERAL	RANGE
3. BASIS FOR CORRECTION							1			
4. DISTRIBUTION							2			
5. PROJECTILE							3			
6. AMMUNITION LOT/CHARGE							4			
7. FUZE							5			
8. NUMBER OF ROUNDS							6			
9. RANGE SPREAD, LATERAL SPREAD, ZONE OR SWEEP							AIMING CIRCLE			
10. TIME OF OPENING FIRE										
11. TARGET NUMBER							PRIORITY TARGET INFORMATION FINAL PROTECTIVE FIRE/ COPPERHEAD			
FIRE COMMAND STANDARDS					ADJUST FIRE	FIRE FOR EFFECT	GRID		TARGET NUMBER	
12. WARNING ORDER										
13. PIECE TO FOLLOW/PIECE TO FIRE/METHOD OF FIRE										
14. SPECIAL INSTRUCTIONS										
15. PROJECTILE										
16. AMMUNITION LOT										
17. FUZE/FUZE SETTING										
18. DEFLECTION										
19. QUADRANT ELEVATION										
20. METHOD OF FIRE										
BATTERY AMMUNITION COUNT	BATTERY DATA	GRID/ALTITUDE	AZIMUTH	CALL SIGN	25. FIRE PLAN					
					KNOWN POINT/TARGET	LOCATION	TIME ON TARGET	UNIT OF FIRE		
BATTERY GFT SETTINGS										
21. HIGH EXPLOSIVE										
22. DUAL-PURPOSE IMPROVED CONVENTIONAL MUNITIONS										
23. ROCKET-ASSISTED PROJECTILES										
24. NUCLEAR STANDARD										
REMARKS										

MUZZLE VELOCITY RECORD					DATE	POWDER GROUP	
For use of this form, see FM 6-40; the proponent agency is TRADOC.							
FIRST LOT CALIBRATION							
SHELL/FAMILY		FIRST POWDER LOT NUMBER	GUN NUMBER/CHARGE FIRED				
ITEMS		1/	2/	3/	4/	5/	6/
1. WEAPON BUMPER NUMBER							
2. WEAPON TUBE NUMBER							
3. FIRST LOT CHARGE STANDARD MUZZLE VELOCITY							
4. CALIBRATED MUZZLE VELOCITY							
5. FIRST LOT PIECE MUZZLE VELOCITY VARIATION							
SECOND LOT CALIBRATION/INFERENCE							
SHELL/FAMILY		POWDER GROUP	GUN NUMBER/CHARGE FIRED				
ITEMS		1/	2/	3/	4/	5/	6/
6. SECOND LOT CHARGE STANDARD MUZZLE VELOCITY							
7. SECOND LOT CALIBRATED MUZZLE VELOCITY							
8. FIRST LOT PIECE MUZZLE VELOCITY VARIATION (5)							
9. CHANGE IN MUZZLE VELOCITY VARIATION							
10. FIRST LOT PIECE MUZZLE VELOCITY VARIATION (5)							
11. CHANGE IN MUZZLE VELOCITY VARIATION (9)							
12. SECOND LOT INFERRED FIRING UNIT MUZZLE VELOCITY VARIATION							
13. SECOND LOT STANDARD MUZZLE VELOCITY							
14. SECOND LOT CALIBRATED MUZZLE VELOCITY							
15. SECOND LOT PIECE MUZZLE VELOCITY VARIATION							

M90 VELOCIMETER WORK SHEET

For use of this form, see FM 6-40; the proponent agency is TRADOC.

CHARGE GROUP	DATE/TIME	PROJECTILE/FAMILY
PROJECTILE MODEL	POWDER LOT NUMBER	PROJECTILE WEIGHT

ITEMS <i>a</i>	GUN 1 CHARGE <i>b</i>	GUN 2 CHARGE <i>c</i>	GUN 3 CHARGE <i>d</i>	GUN 4 CHARGE <i>e</i>	GUN 5 CHARGE <i>f</i>	GUN 6 CHARGE <i>g</i>
1. WEAPON BUMPER NUMBER						
2. WEAPON TUBE NUMBER						
3. STARTING POWDER TEMPERATURE						
4. ENDING POWDER TEMPERATURE						
5. AVERAGE POWDER TEMPERATURE						

M90 VELOCIMETER READOUT

ROUND 1						
ROUND 2						
ROUND 3						
ROUND 4						
ROUND 5						
ROUND 6						
ROUND 7						
ROUND 8						
READOUT AVERAGE						
6. MUZZLE VELOCITY CORRECTION FOR NONSTANDARD CONDITIONS						
7. CALIBRATED MUZZLE VELOCITY						
8. NUMBER OF WARMUP ROUNDS FIRED						

REMARKS

APPENDIX K

GUNNERY TEAM PROCEDURES USING THE GROUND/VEHICULAR LASER LOCATOR DESIGNATOR

K-1. SELF-LOCATION

a. An observer equipped with the ground/vehicular laser locator designator (G/VLLD operator) can use its distance-, direction-, and azimuth-determining capability to locate himself. In this procedure, he uses the G/VLLD to determine the direction, distance, and vertical angle to two known points separated by at least 150 mils and preferably more than 300 mils. Normally the G/VLLD will be used with the FIST DMD for self-location. In static situations, the FDC may locate the G/VLLD position on the firing chart (by resection) by constructing an arc with a radius of the reported distance from each prearranged point in the general direction of the back azimuth to the points. The intersection of the arcs is the G/VLLD location. The separation of the prearranged points ensures that the arcs will intersect at a distinct point. After determining the G/VLLD location, the FDC measures the correct orienting azimuth to one of the prearranged points. The location and azimuth are then sent to the G/VLLD operator through secure means. The FDC may also use the hand-held calculator.

b. Location of the G/VLLD by the FDC can be done by use of two known points, one known point and one burst, or two bursts.

K-2. LOCATION OF THE G/VLLD BY USE OF TWO KNOWN POINTS

a. The G/VLLD operator uses two known points as the prearranged points (fig K-1). Known points may be established by survey, firing, or measuring from a map. The two known points method is used when the FIST DMD is not available. When measuring from a map, two techniques can be used.

(1) The G/VLLD operator can provide eight-place grids to the known points.

(2) The G/VLLD operator can give the FDC the general location (six-place grid) and description of the known point. Then the FDC determines an accurate location (eight-place grid) through map/terrain analysis by use of a map and a coordinate scale.

b. Once the known point locations have been established by the FDC, the operator

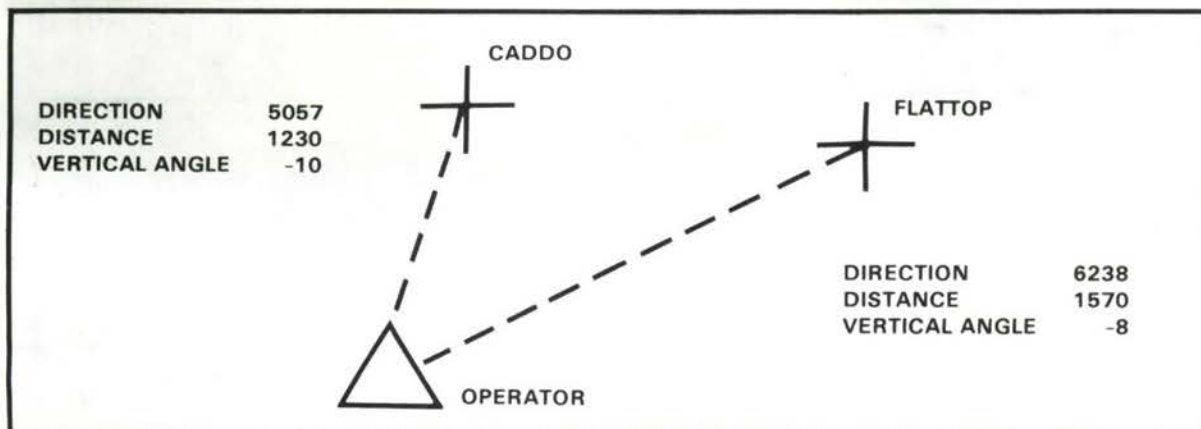


Figure K-1. Location by use of two known points.

reports G/VLLD polar plot data to the FDC for each of the known points.

Note. All numerical values in the following examples are encoded.

EXAMPLE:

T2A42 THIS IS B6H23, SELF-LOCATION, OVER.

KNOWN POINT FLATTOP, DIRECTION 6238, DISTANCE 1570, VERTICAL ANGLE -8, OVER.

KNOWN POINT CADD0, DIRECTION 5057, DISTANCE 1230, VERTICAL ANGLE -10, OVER.

c. The FDC determines the location of the G/VLLD as follows:

(1) On a firing chart, the chart operator constructs an arc from each known point by use of an RDP at the distance reported by the G/VLLD operator. The arc is centered along the back azimuth of the G/VLLD operator's reported direction to the known point. The intersection of the two arcs is the G/VLLD location.

Note. The G/VLLD location can be further refined by taking the reported distance and vertical angle of each known point and computing the G/VLLD operator's known point VI by use of a GST (chap 9). Each VI can then be applied to its known point altitude to determine the G/VLLD operator's altitude. The altitude of the arc intersection is then compared with the computed G/VLLD operator's altitude. If

there is a difference, the determined G/VLLD location may be adjusted along the azimuth, midway between the azimuths of the two known points to a point where the map altitude matches the computed G/VLLD operator's altitude. Only minor adjustments should be needed, if any.

(2) The chart operator measures the correct azimuth to one of the known points from the plotted G/VLLD location.

(3) The FDC encodes and sends the G/VLLD operator his location (eight-place grid) and his direction to the known point.

EXAMPLE:

T2A54 THIS IS B6L54, LOCATION 4725 3824, DIRECTION TO CADD0 5039, OVER.

(4) From a map, the FDC determines the altitude of the G/VLLD operator's location if not already determined.

(5) The FDC records the G/VLLD operator's location and altitude and stores them in the FDC ballistic computer. Location by use of two known points is the most accurate method of locating a G/VLLD.

K-3. LOCATION OF THE G/VLLD BY USE OF ONE KNOWN POINT AND ONE BURST

a. If only one known point is available to the G/VLLD operator, he may request that a round (HE or WP) be fired to establish the second known point (fig K-2). The G/VLLD

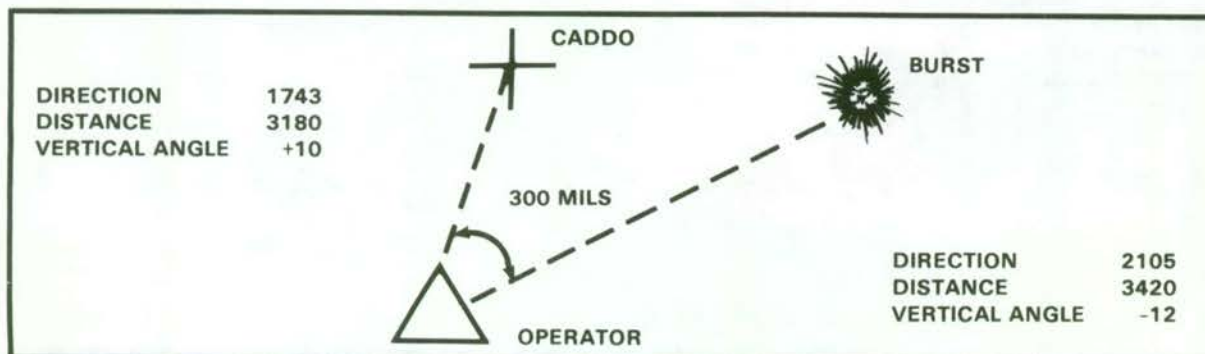


Figure K-2. Location by use of one known point and one burst.

operator will provide the location for the round to burst. Graze bursts should be used.

EXAMPLE:

Observer sends to the FDC—

T2A42 THIS IS K3M47, SELF-LOCATION, 1 ROUND, OVER.

KNOWN POINT CADD0, DIRECTION 1743, DISTANCE 3180, VERTICAL ANGLE +10, OVER.

1 ROUND GRID 598360, OVER.
(round fired and observed)

DIRECTION 2105, DISTANCE 3420, VERTICAL ANGLE -12, OVER.

b. The procedures used by the FDC to determine the location of the G/VLLD are the same as those used for two known points. The grid of the burst location is reported by the G/VLLD operator and is used instead of the second known point. The vertical angle reported to the one known point can be used to further refine the G/VLLD location. The determined G/VLLD location can be adjusted along the azimuth to the known point to a point where the map altitude matches the computed G/VLLD operator's altitude.

K-4. LOCATION OF THE G/VLLD BY USE OF TWO BURSTS

a. When no known points are available to the G/VLLD operator, he may request that

two rounds be fired to establish the known points (fig K-3). Graze bursts should be used.

EXAMPLE:

T2A24 THIS IS T2A58, SELF-LOCATION, 2 ROUNDS, OVER.

1 ROUND, GRID 603368, OVER.
(round fired and observed)

DIRECTION 6398, DISTANCE 4110, VERTICAL ANGLE -9, 1 ROUND, GRID 564381, OVER.
(round fired and observed)

DIRECTION 5927, DISTANCE 3840, VERTICAL ANGLE -11, OVER.

b. The procedures used by the FDC to determine the G/VLLD location are the same as those used for the two methods previously described. After determining the G/VLLD location, the FDC measures the azimuth to the second burst. The determined G/VLLD location and azimuth are sent to the G/VLLD operator.

EXAMPLE:

T2A58 THIS IS T2A24, LOCATION 58723 34231, DIRECTION TO SECOND ROUND 5918, OVER.

c. Self-location by use of two bursts is the least accurate method, because accuracy depends on the accuracy of the firing data being used. This method is not recommended unless current registration corrections or accurate muzzle velocities, battery location, and met are available.

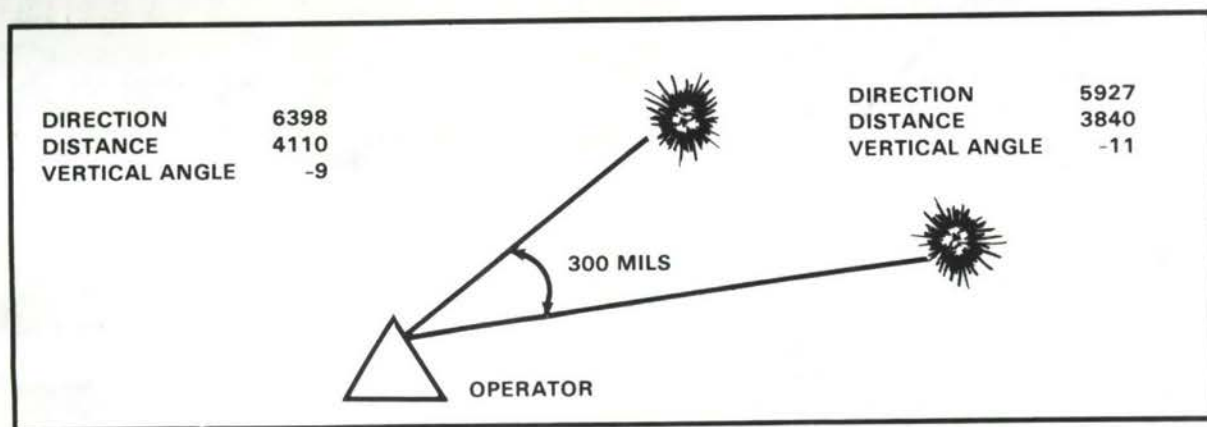


Figure K-3. Location by use of two bursts.

K-5. G/VLLD LOCATION BY USE OF FADAC/BCS

The reported self-location data can be processed by use of the SURVEY (E4) function in the FADAC or BCS SPRT location routines.

K-6. SECOND G/VLLD OPERATOR ASSISTANCE

An operator emplacing a G/VLLD may have no known points in his area (fig K-4). Rather than accept the inherent inaccuracies of self-location by use of two bursts, the FDC may recommend that the G/VLLD operator contact a nearby operator that has an accurately located G/VLLD and have him establish some known points in the area of the G/VLLD being located. Both G/VLLD operators must be able to see a common area well enough to clearly identify and locate prominent objects that can serve as known points. Once agreeable points have been identified, they can be established as known points as in figure K-4.

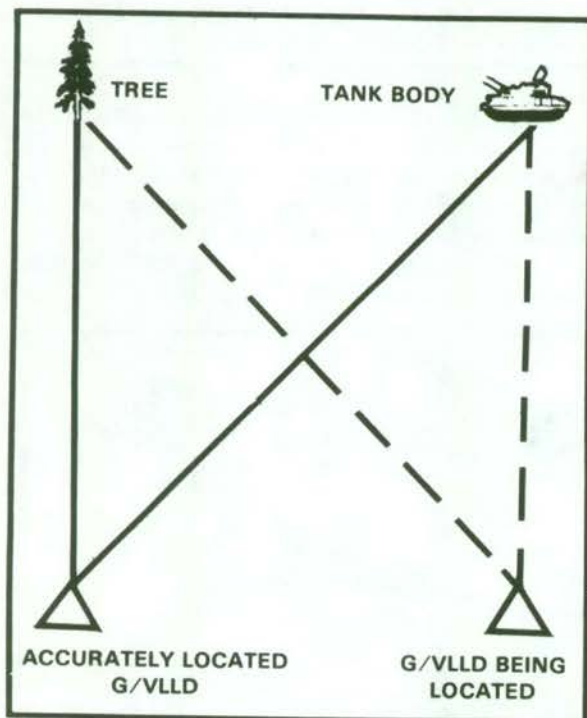


Figure K-4. Second G/VLLD operator assistance.

EXAMPLE:

A G/VLLD operator (T2A23) has no known points in his area. The FDC (B6H16) instructs him to contact a nearby G/VLLD operator having an accurately located G/VLLD (T2A47) for assistance in establishing known points in his area. Acceptable points have been identified. They are sent to the FDC as known points.

B6H16, THIS IS T2A47, KNOWN POINTS FOR T2A23, OVER.

KNOWN POINT TREE, DIRECTION 0832, DISTANCE 5740, VERTICAL ANGLE -9, OVER.

KNOWN POINT TANK BODY, DIRECTION 0947, DISTANCE, 6370, VERTICAL ANGLE -11, OVER.

The FDC plots the known point locations. T2A23 initiates self-location by use of two known points.

B6H16, THIS IS T2A23, SELF-LOCATION, OVER.

KNOWN POINT TREE, DIRECTION 5823, DISTANCE 6240, VERTICAL ANGLE -10, KNOWN POINT TANK BODY, DIRECTION 6207, DISTANCE 5970, VERTICAL ANGLE -14, OVER.

T2A23, THIS IS B6H16, LOCATION 3837 4512, DIRECTION TO TREE 5818, OVER.

Note. All transmissions should be made on the same communications net so that all three stations can monitor the information being passed.

K-7. LOCATION BY SIMULTANEOUS OBSERVATION

a. During periods of limited visibility, a G/VLLD operator with an accurately located G/VLLD can help determine the location of another G/VLLD by performing simultaneous observation with the other G/VLLD operator on two illumination rounds. Both G/VLLD operators must be able to see and

lase the flares (fig K-5). The operator with the accurately located G/VLLD acts as the controlling station and initiates the call for fire.

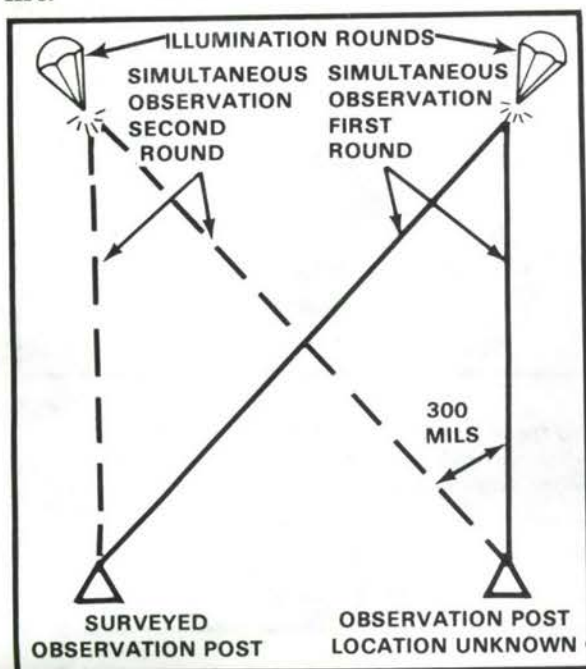


Figure K-5. Location by simultaneous observation.

EXAMPLE:

T2A47 is the operator of the accurately located G/VLLD. T2A23 is the operator of the G/VLLD being located. B6H16 is the battery fire direction center. Coordination between T2A47 and T2A23 has already been accomplished.

B6H16 THIS IS T2A47, SIMULTANEOUS OBSERVATION WITH T2A23, OVER.

1 ROUND, GRID 374522, 1 ROUND, GRID 391516, OVER.

ILLUMINATION, BY ROUND AT MY COMMAND, OVER.

T2A47, THIS IS T2A23, READY TO OBSERVE, OVER.

T2A47, THIS IS T2A16, READY, OVER.

b. As each illumination round is fired, the operator with the accurately located G/VLLD coordinates simultaneous lasing of the flares. Both operators lase each flare simultaneously and send the data to the fire direction center.

EXAMPLE:

B6H16, THIS IS T2A47, DIRECTION 0437, DISTANCE 3780, VERTICAL ANGLE +21, OVER.

B6H16, THIS IS T2A23, DIRECTION 6377, DISTANCE 4120, VERTICAL ANGLE +23, OVER.

c. When observation data for both rounds have been obtained, the FDC determines the location of the previously unlocated G/VLLD. This is done by using the polar plot data from the accurately located G/VLLD and placing a plotting pin at the location of each illumination round at the time of lasing. These pin locations are used as known points. The location of the unlocated G/VLLD is then determined by using the same procedures used by the FDC for self-location by use of two known points. After the G/VLLD location has been determined, the azimuth to the pin location representing the second illumination round is measured. The resulting information is sent to the operator of the newly located G/VLLD.

EXAMPLE:

T2A23 THIS IS H6E26, LOCATION 9164 3842, DIRECTION TO SECOND ROUND 0317, OVER.

K-8. OPERATOR CLOUD HEIGHT

In addition to his location, the G/VLLD operator reports the height of the clouds over his position (operator cloud height) to the battery FDC supporting him (fig K-6). This

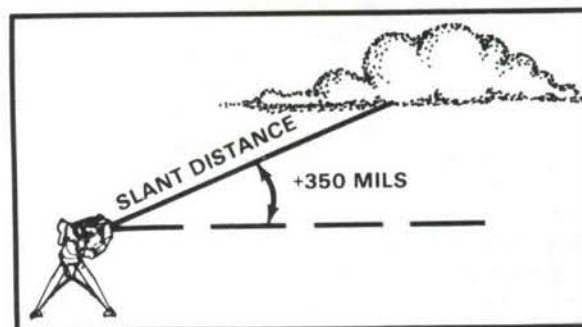


Figure K-6. Determining operator cloud height.

Table K-1. G/VLLD operator cloud height.

RANGE	0	100	200	300	400
1500	510	540	570	610	640
2000	670	710	740	780	810
2500	840	880	910	940	980
3000	1010	1040	1080	1110	1140
3500	1180	1210	1250	1280	1310
4000	1350	1380	1420	1450	1480
4500	1520	1550	1580	1620	1650
5000	1680	1720	1750	1790	1820
5500	1850	1890	1920	1950	1990
6000	2020	2060	2090	2120	

Notes.

1. A similar table is on the cover of the Copperhead footprint templates. The operator should report operator cloud height as soon as possible after occupying a position. He then reports changes only when the change in operator cloud height exceeds 100 meters.
2. An increase or decrease of 300 meters in measured slant range corresponds to an approximate 100-meter increase or decrease in cloud height.
3. Enter table with range to nearest 100 meters (interpolation required).

information is essential for computing firing data for Copperhead. The reported operator cloud height is recorded by the supporting battery FDC, which forwards the information to the battalion FDC. The G/VLLD operator updates his reported operator cloud height when the measured change in height is 100 meters or greater. Cloud height is measured by setting a vertical angle of +350 mils on the G/VLLD and lasing the distance to the cloud cover. The cloud height table (table K-1) is used to convert the distance to the cloud height.

K-9. ADJUSTMENT OF FIRE

a. With the G/VLLD located and oriented, the resulting target locations are accurate enough for first round fire for effect. However, some of the other requirements for accurately predicted fire may be lacking. When the G/VLLD operator is in doubt as to whether he can achieve first round FFE on the target, an adjust fire mission is requested. When the first round impacts, the G/VLLD operator determines the angular deviation by

determining the difference between the measured direction to the target and the measured direction to the burst of the adjusting round (fig K-7).

b. If the angular deviation is greater than 100 mils, the mil relation and operator adjustment techniques do not provide accurate adjustments. In this case, the G/VLLD operator sends the laser polar plot data of the burst to the FDC to compute the shift.

EXAMPLE:

BURST DIRECTION 5872, DISTANCE 4350, VERTICAL ANGLE -11, FIRE FOR EFFECT, OVER.

The manual FDC computes the shift by using the M17 plotting board. The FDC orients the plotting board on the OT direction given in the call for fire and plots the target at the OT distance measured with the G/VLLD. The G/VLLD operator sends the FDC the direction, distance, and vertical angle to the adjusting round. The FDC orients the plotting board on the operator-burst (OB)

direction and plots the burst at the distance measured with the G/VLLD. The FDC reorients the plotting board on the OT direction and determines the lateral and range shifts required to move the burst of the adjusting round to the target. The accuracy is sufficient to permit fire for effect on the target following a large shift from the initial adjusting point.

c. If no plotting board is available, sine and cosine functions can be used to determine the correct shift. Rough sine functions from the TFT or from TM 6-230 are used. See the introduction of TM 6-230 for explanation of its use. Angular values can also be determined by use of the hand-held calculator.

K-10. AUXILIARY AIMING POINT

a. To achieve surprise on a target when FFE is not possible, the auxiliary aiming point method may be used. This method

identifies an adjusting point that will place an adjusting round 100 to 300 mils away from the intended target.

EXAMPLE:

B6H16, THIS IS T2A23, ADJUST FIRE, SHIFT AUXILIARY ADJUSTING POINT, OVER.

TARGET DIRECTION 220, DISTANCE 3680, VERTICAL ANGLE +2, OVER.

ADJUSTING POINT GRID 633374, OVER.

BATTALION ASSEMBLY AREA, ICM IN EFFECT, OVER.

b. When the adjusting round bursts, the G/VLLD operator lases the burst and sends the data to the FDC (fig K-8). The FDC determines the shift required to move the burst to the auxiliary adjusting point. That shift is applied to the target location, defining the target aiming point location. Fire-for-effect data are then computed at the target aiming point.

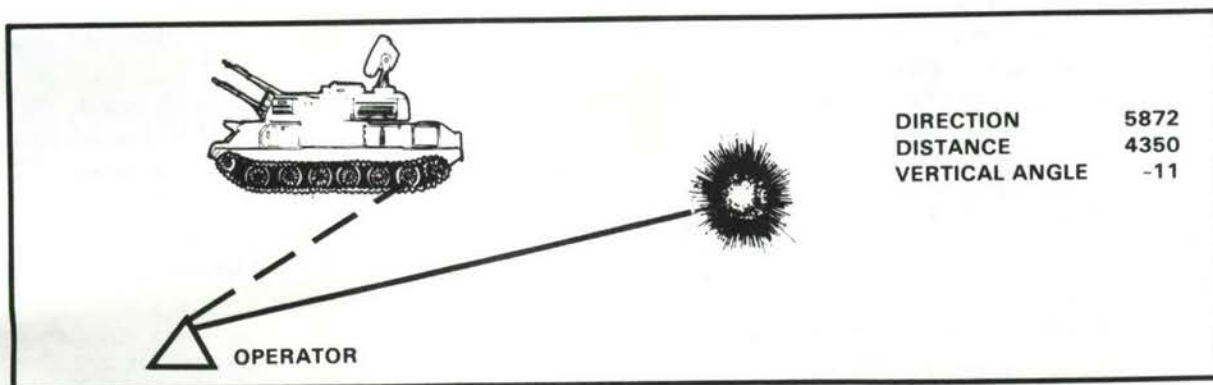


Figure K-7. Use of the G/VLLD to determine subsequent corrections.

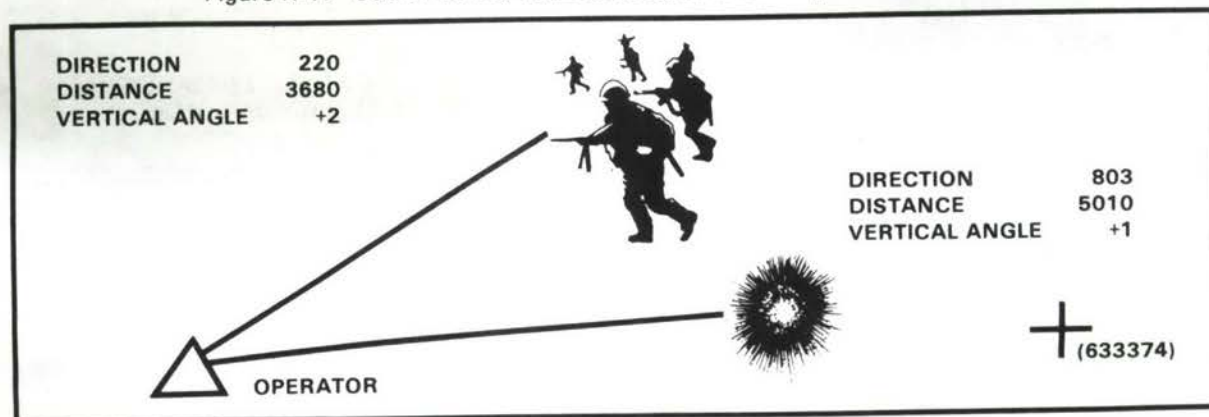


Figure K-8. Adjust fire from auxiliary aiming point.

K-11. REGISTRATIONS

a. High-Burst or Mean-Point-of-Impact Registration. The G/VLLD may be used to conduct an HB/MPI registration. Orienting data are provided by the FDC, and one G/VLLD-equipped observer is required. He determines the direction, distance, and vertical angle for each burst and provides the round-by-round data to the FDC. The FDC determines the *average* direction, distance, and vertical angle to the high burst. Using these averages, the FDC determines the location of the HB/MPI and registration corrections as in a normal HB registration. The G/VLLD must be accurately located and oriented before this technique can be used.

CAUTION: Safety restrictions in training may prevent lasing a high burst if it is above the skyline. Lasing above the skyline requires permission from range control.

b. Precision Registration. In the conduct of a precision registration, the operator uses the G/VLLD to determine corrections as described in the procedures for using the G/VLLD in the adjustment of fire. When the adjusting round is brought within 50 meters of the registration point (100 meters when the probable error in range is 25 meters or more), the adjustment procedures for normal precision fire are used. Precision registrations should be conducted only when the G/VLLD has not been accurately located.

K-12. ABBREVIATED REGISTRATION TECHNIQUES

The tactical situation or ammunition constraints may prohibit conducting a full-scale HB/MPI or precision registration.

In an abbreviated registration, the G/VLLD operator lases the burst of the first adjusting round and determines corrections in the same manner as for the adjustment of fire by use of the G/VLLD. The FDC computes the data for the second round and fires it. The G/VLLD operator lases the second burst and reports the corrections. The FDC determines adjusted data. These adjusted data are not fired. Registration data are based on the data obtained on the two adjusting rounds. If a time registration has also been requested, two airbursts are obtained to establish the mean height of burst. The operator sends corrections to adjust the mean height of burst to 20 meters.

EXAMPLE:

T2A23, THIS IS B6H26, ABBREVIATED REGISTRATION, REGISTRATION POINT 1, QUICK AND TIME, OVER.

B6H26, THIS IS T2A23, DIRECTION 6216, OVER.

(First adjusting round is fired. Angle of deviation is greater than 100 mils.)

DIRECTION 6327, DISTANCE 5430, VERTICAL ANGLE -11, OVER.

(Data are computed and second adjusting round is fired. Angle of deviation is less than 100 mils.)

LEFT 30, ADD 50, RECORD AS REGISTRATION POINT 1, TIME, REPEAT, OVER.

(Adjusted deflection and elevation are determined. Data for fuze time are computed. One HE round at a time is fired with fuze time until an airburst is obtained. Then two HE/time rounds are fired.)

DOWN 25, RECORD AS TIME REGISTRATION POINT 1, END OF MISSION.

(Adjusted time is determined.)

GLOSSARY

DEFINITIONS OF COMMON TERMS

A

ablation

- the loss of surface material by burning or charring caused by the friction of a fluid moving past an object at high speed and/or temperature. The effect is used to advantage in cooling high-speed bodies such as ballistic missile warhead sections or other space reentry vehicles.

ADD

- a correction reported by an observer or a spotter to indicate that an increase in range along the observer-target line is desired.

ADJUST

- an order to the observer or spotter to initiate an adjustment on a designated target.

adjusted elevation

- elevation based on firing and computed to place the center of impact at a given or known range.

ADJUST FIRE

- an order or request to initiate an adjustment.
- a method of control transmitted in the call for fire by the observer or the spotter to indicate that he will control the adjustment.

adjustment

- a process used in artillery and naval gunfire to obtain the correct direction, range, and height of burst (if time fuzes are used) in engaging a target by observed fire.

AIR

- a spotting or an observation by a spotter or an observer to indicate that a burst or group of bursts occurred before impact (also see graze).

airburst

- an explosion of a bomb or projectile above the surface as distinguished from an explosion on contact with the surface or after penetration of the surface.

- the explosion of a nuclear weapon in the air at a height of burst greater than the maximum radius of the fireball.

ammunition lot number

- the code number that identifies a particular quantity of ammunition from one manufacturer. The number is assigned to each lot of ammunition when it is manufactured.

angle of departure

- in artillery, the vertical angle between the tangent to the trajectory at the origin and the horizontal or base of the trajectory.

angle of fall

- the vertical angle between the tangent to the trajectory at the level point and the level base of the trajectory.

angle of site

- the vertical angle between the level base of the trajectory/horizontal and the line of site.

angle T

- the angle formed at the target by the intersection of the gun-target line and the observer-target line.

AT MY COMMAND

- the command used to indicate desire to control the exact time of delivery of fire.

axis of tube

- the straight line through the center of the bore at the breech end and the center of the bore at the muzzle end.

B

ballistic density

- the computed constant air density that would have the same total effect on a projectile during its flight as the varying densities actually encountered.

ballistics

- the science or art that deals with motion, behavior, appearance, or modification of

missiles or other vehicles acted upon by propellants, wind, gravity, temperature, or any other modifying substance, condition, or force.

barrel

- a metal or plastic tube through which ammunition is fired and which controls the initial direction of the projectile.
- a standard unit of measure of liquids in petroleum pipeline and storage operations—42 US standard gallons.

barrel erosion

- the wearing away of the inner surface of the bore due to the combined effects of gas, washing, scoring, and mechanical abrasion. Barrel erosion causes a reduction in muzzle velocity.

base of trajectory

- a line extending from the muzzle of the tube that intersects the trajectory at the same altitude as the muzzle.

BATTERY ADJUST

- a command given to alert all pieces of the battery.

battery center

- a point materialized on the ground at the approximate geometric center of the battery position; the chart location of the battery.

battery front

- the lateral distance between the flank guns of a battery.

battery (troop) left (right)

- a method of fire in which weapons are discharged from the left (right), one after the other, at 5-second intervals.

BATTERY 1 (or more) ROUND

- a method of fire announced as a fire command that directs that all pieces be fired at the same time.

beehive (ammunition)

- a type of ammunition designed for use in defending a position against massed personnel attacks.

boat tail

- the conical section of a ballistic body that progressively decreases in diameter toward the tail to reduce overall aerodynamic drag.

boost cutoff

- the point in a trajectory of a rocket or missile at which the boost phase terminates.

bracketing

- a method of adjusting fire in which a bracket is established by obtaining an OVER and a SHORT along the spotting line and then successively splitting the bracket in half until a TARGET HIT or desired bracket is obtained.

breechblock

- a movable steel block that closes the breech of a cannon.

breech ring

- the breechblock housing, screwed or shrunk onto the rear of a cannon tube, in which the breechblock engages.

burster

- an explosive charge used to break open and spread the contents of chemical projectiles, bombs, or mines.

C

caliber

- the diameter of the bore of a gun. In rifled gun barrels, the caliber is obtained by measuring between opposite lands. A caliber .45 revolver has a barrel with a land diameter of 45/100 of an inch.
- the diameter of a projectile.
- a unit of measure used to express the length of the bore of the weapon. The number of calibers is determined by dividing the length of the bore of the weapon, from the breech face of the tube to the muzzle, by the diameter of its bore. A gun tube with the bore 40 feet (480 inches) long and 12 inches in diameter is said to be 40 calibers long.

call for fire

- a request for fire containing data necessary for obtaining the required fire on a target.

cancel

- when coupled with an order other than quantity or type of ammunition, rescinds that order.

cannon

- a complete assembly consisting of an artillery tube, a breech mechanism, a firing

mechanism, and a sighting system mounted on a carriage.

cannoneer

—a member of an artillery gun or howitzer crew whose primary duty is servicing the piece.

cannot observe

—a type of fire control which indicates that the observer or spotter will be unable to adjust fire but believes a target exists at the given location and is of sufficient importance to justify firing on it without adjustment or observation.

centrifugal force

—the force acting on a rotating body that tends to move its parts outward and away from the center of rotation.

charge

—the propellant of semifixed or separate-loading ammunition.

CHECK FIRING

—a command used to cause a temporary halt in firing.

chemical agent

—a chemical compound which, when suitably disseminated, produces incapacitating, lethal, or damaging effects on men, animals, plants, or materials.

circular error probable

—an indicator of the accuracy of a missile (projectile) used as a factor in determining probable damage to a target. It is the radius of a circle within which half the missiles (projectiles) are expected to fall.

complementary angle of site (comp site)

—the correction to compensate for the error made in assuming rigidity of the trajectory.

complementary range (comp range)

—range corrections corresponding to the complementary angle of site. These range corrections are tabulated in the firing tables and are a function of chart range and height above (below) the gun.

complete round

—a term applied to an assemblage of explosive and nonexplosive components designed to perform a specific function at the time and under the conditions desired. Examples of complete rounds of ammunition are *separate loading*,

consisting of a primer, a propelling charge, and, except for blank ammunition, a projectile and a fuze; and *fixed or semifixed*, consisting of a primer, a propelling charge, a cartridge case, a projectile, and, except when a solid projectile is used, a fuze.

computer

—a mechanical or electromechanical instrument used to solve mathematical problems. It is used to obtain data for artillery and for navigation. A computer used with air defense artillery receives continuous present-position data on aircraft or other moving targets and continuously calculates firing data for use against such targets; data computer.

—a fire direction center operator who computes data for laying and firing artillery guns.

continuous fires

—fire conducted at a normal rate without interruption for applying adjustment corrections.

—in field artillery and naval gunfire, loading and firing as rapidly as possible, consistent with accuracy, within the prescribed rate of fire for the weapon. Firing will continue until the command **CHECK FIRING**, **CEASE LOADING**, or **END OF MISSION** is given.

continuous illumination

—a type of fire in which illuminating projectiles are fired at specified time intervals to provide uninterrupted lighting on the target or specified area.

CONVERGE

—a request or command used in a call for fire to indicate that the observer or spotter desires a sheaf in which the planes of fire intersect at a point.

converged sheaf

—a type of sheaf in which each gun fires at a unique time, deflection, and quadrant elevation to cause the rounds to impact at the same point.

cook off

—the functioning of a chambered round of ammunition initiated by the heat of the weapon.

coordinated illumination

- the firing of illuminating rounds to illuminate a target and the surrounding area only at the time required for spotting and adjusting high-explosive fire.

coppering

- metal fouling left in the bore of a weapon by the rotating band or jacket of a projectile.

Coriolis effect

- the apparent change in range or azimuth caused by the rotational effects of the earth.

correction

- any change in firing data to bring the mean point of impact or burst closer to the target.
- a communications proword to indicate that an error in data has been announced and that corrected data will follow.

crest

- a terrain feature of such altitude that it restricts fire or observation in the area beyond, resulting in dead space, limitation of the minimum elevation, or both.

CRESTED

- a report that indicates that engagement of a target or observation of an area is not possible because of an obstacle or intervening crest.

D

deflection

- the setting on the scale of the sight of a weapon to place the line of fire in the desired direction.
- the horizontal clockwise angle between the axis of the tube and the line of sight.

deflection index

- a fine line constructed on the firing chart and used to measure deflection with the range-deflection protractor.

deflection limits

- right and left traverse limits that establish the lateral limits of a designated impact area.

deflection probable error

- the directional error caused by dispersion that will be exceeded as often as not in an infinite number of rounds fired at a single deflection. It is one eighth the width of the

dispersion pattern at its greatest width. This value is given in the firing tables.

delay action

- the predetermined delayed explosion of an ammunition item after activation of the fuze.

description of target

- an element in the call for fire in which the observer or spotter describes the installation, personnel, equipment, or activity to be taken under fire.

destruction fire

- fire delivered for the sole purpose of destroying materiel objects.

deviation

- the distance by which a point of impact or burst misses the target.
- the angular difference between magnetic and compass headings.

direction

- a term used by a spotter or an observer in a call for fire to indicate the bearing of the spotting line.

dispersion pattern

- the dispersion of a series of rounds fired from one weapon or a group of weapons under conditions as nearly identical as possible. The points of bursts or impacts are dispersed about a point called the mean point of impact.

dispersion rectangle

- a table that shows the probable distribution of a succession of shots fired with the same firing data. A dispersion rectangle consists of a diagram made up of 64 zones. The table shows the percentage of shots that may be expected to fall within each zone.

doubtful

- a term used by the observer or spotter to indicate that he was unable to determine the difference in range between the target and a round or rounds.

DOWN

- a term transmitted in a call for fire to indicate that the target is at a lower altitude than the reference point used in identifying the target.

- a correction reported by an observer or a spotter in time fire to indicate that a decrease in height of burst is desired.

drag

- the resistance of the atmosphere to the movement of a projectile through it. Drag is directly proportional to the diameter and velocity of the projectile and the density of the air.

drift

- the lateral deviation of the trajectory from the plane of departure caused by the rotation of the projectile. As a result of the deviation, the horizontal projection of the trajectory would be a curved line rather than a straight line. The deviation is always to the right with a projectile having a right-hand spin.

DROP

- a correction reported by an observer or a spotter to indicate that a decrease in range along the observer-target line is desired.

E

elevate

- to raise the muzzle or warhead end of a weapon.

elevation

- the vertical angle between horizontal and the axis of the bore or rail of a weapon required for a projectile to reach a prescribed range.

emplacement

- a prepared position for one or more weapons or pieces of equipment for the purpose of protection against hostile fire or bombardment.
- the act of fixing a gun in a prepared position from which it may be fired.

END OF MISSION

- an order given to terminate firing on a specific target.

ephemeris

- a tabular statement of the assigned places of celestial bodies for regular intervals.

exterior ballistics

- a subdivision of ballistics that deals with the phenomena associated with the aerodynamic performance of missiles.

F

final protective fire

- an immediately available, prearranged barrier of fire designed to impede enemy movement across defensive lines or areas.

fins

- aerodynamic surfaces externally attached to a missile or projectile designed to provide stability and control during flight.

FIRE

- the command given to discharge a weapon.

fire control

- all operations connected with the planning, preparation, and actual application of fire on a target.

fire direction

- the tactical employment of firepower. The exercise of tactical command of one or more units in the selection of targets, the concentration or distribution of fire, and the allocation of ammunition for each mission. Fire direction also includes the methods and techniques used in fire direction centers to convert target information into appropriate fire commands.

fire direction center

- the element of a command post consisting of gunnery and communications personnel and equipment by means of which the commander exercises fire direction and/or fire control. The fire direction center receives target intelligence and requests for fire and translates them into appropriate fire direction.

FIRE FOR EFFECT

- a command to indicate that fire for effect is desired.

fire for effect

- fire that is intended to achieve a desired effect on the target.

FIRE MISSION

- an order used to alert the battery area and to indicate that the message following is a call for fire.

fire mission

- a specific assignment given to a fire unit as part of a definite plan.

firing data

- all data necessary for firing an artillery piece at a given objective. Such data may be determined by computation and then transmitted by verbal commands or may be applied electromechanically by one of the several types of directing devices.

firing table

- a table or chart giving the data needed for firing a weapon accurately on a target under standard conditions. It also gives the corrections that must be made for special conditions such as winds or variations of temperature.

fixed ammunition

- ammunition in which the cartridge case is permanently attached to the projectile.

FUZE

- a command or request to indicate the type of fuze action desired; for example, delay, quick, time, or VT.

fuze

- a device used in munitions to initiate a detonation.

fuze delay

- a fuze that has a delay element incorporated into the fuze train.

fuze super quick

- a fuze that functions immediately upon impact of the projectile with the target. Action of this type of fuze is the quickest possible. The firing pin is driven into the primer immediately upon first contact of the missile with the target; hence, the missile functions at the surface of the target. Also called instantaneous fuze.

fuze time

- (fuze mechanical time super quick) a fuze that contains a graduated time element to regulate the time interval after which the fuze will function.

fuze VT

- see proximity fuze.

G

GRAZE

- a spotting or observation reported by a spotter or an observer to indicate that all bursts occurred on impact.

grid

- a term used when giving the location of a geographic point by grid coordinates.
- two sets of parallel lines intersecting at right angles and forming squares. The grid is superimposed on maps, charts, and other similar representations of the earth's surface in an accurate and consistent manner to permit identification of ground locations with respect to other locations and to permit the computation of direction and distance to other points.

grid convergence

- the angular difference in direction between grid north and true north. It is measured east or west from true north.

grid coordinates

- numbers and letters of a coordinate system that designate a point on a gridded map, photograph, or chart.

grid line

- one of the lines in a grid system; the line used to divide a map into squares. East-west lines in a grid system are X lines, and north-south lines are Y lines.

grid magnetic angle

- the angular difference in direction between grid north and magnetic north. It is measured east or west from grid north. Grid magnetic angle is sometimes called grivation and/or grid variation.

grid north

- the northerly or zero direction indicated by the grid datum of direction reference.

grid system

- imaginary lines dividing the earth into sectors to aid in the location of points.

gun-target line

- an imaginary straight line from the gun to the target.

H

height of burst

- the vertical distance from the earth's surface or the target to the point of burst.
- for nuclear weapons, the optimum height of burst for a particular target (or area) at which it is estimated a weapon of a specified energy yield will produce a certain desired effect over the maximum possible area.

HIGH ANGLE

—an order or request to obtain high-angle fire.

high-angle fire

—fire delivered at elevations greater than the elevation of maximum range. The range of fire decreases as the angle of elevation increases. Mortars deliver high-angle fire.

high-order detonation

—complete and instantaneous explosion.

I**index**

—a scribed mark on an instrument indicating the number to be read.

indirect fire

—fire delivered at a target that cannot be seen by the aimer.
—fire delivered on a target that is not used as a point of aim for the weapon or the director.

interior ballistics

—a subdivision of ballistics that deals with the phenomena associated with imparting kinetic energy to missiles.

intermediate crest

—a crest lying between the firing point and the forward line of own troops (FLOT) that is not visible from the firing point. The minimum quadrant elevation to clear this crest is the intermediate crest minimum quadrant elevation.

L**lands**

—the raised portion between the grooves in the bore of a gun. Spiral channels cut in the bore of a gun are called grooves.

lateral spread

—a technique used to place the mean point of impact of two or more units 100 meters apart on a line perpendicular to the gun-target line.

lay

—to direct or adjust the aim of a weapon.
—the setting of a weapon for a given range or for a given deflection or for both.

level point

—the point on the descending branch of the trajectory that is at the same altitude as the point of origin. The point at which the trajectory cuts the base. It is sometimes referred to as point of fall.

LINE

—a spotting or an observation reported by a spotter or an observer to indicate that a burst occurred on the spotting line.

line of departure

—a line designated to coordinate the departure of attack or scouting elements; a jump-off line.

line of elevation

—the axis of the bore prolonged.

line of fall

—the line tangent to the trajectory at the level point.

line of sight

—line of vision.
—the straight line between two radio antennas.

line of site

—a straight line joining the origin and a point, usually the target.

LOST

—a spotting or an observation reported by a spotter or an observer to indicate that rounds fired by a gun or mortar were not observed.

low-angle fire

—fire delivered at angles of elevation at or below the elevation that corresponds to the maximum range of the gun and ammunition concerned.

M**maximum ordinate**

—the highest point along the trajectory of a projectile. The difference in altitude (vertical interval) between the origin and the summit.

maximum quadrant elevation

—the greatest vertical angle at which an artillery piece can be laid. The angle is limited generally by the mechanical structure of the piece.

mean height of burst

- the average of the heights of burst of a group of rounds fired with the same firing data.

mean point of impact

- the point whose coordinates are the arithmetic mean of the coordinates of the separate points of impact of a finite number of projectiles fired or released at the same aiming point under a given set of conditions.

mechanical time fuze

- a fuze with a clocklike mechanism that controls the time at which the fuze will function.

meteorological data

- meteorological facts pertaining to the atmosphere such as wind, temperature, air density, and other phenomena which affect military operations.

meteorological datum plane

- the reference plane assumed as a basis or starting point for atmospheric data furnished to artillery. Its altitude is that of the meteorological station.

mil

- a unit of measure for angles based on the angle subtended by 1/6400 of the circumference of a circle. A mil is the angle subtended by one unit at 1,000 units.
- 1/1000 of an inch (wire measurement).

mine action

- the explosion of a shell below the surface of the ground.

minimum quadrant elevation

- the minimum vertical angle of the tube for a specific charge which, when fired, will ensure that the round impacts in the designated impact area.

minimum range

- the least range setting of a gun at which the projectile will clear an obstacle or friendly troops between the gun and the target.
- the shortest distance to which a gun can fire from a given position.

misfire

- failure to fire or explode properly.
- failure of a primer or the propellant of a projectile to function wholly or in part.

- failure of the propellant to ignite when the firing circuit is completed.

MIXED

- a spotting or an observation reported by a spotter or an observer to indicate that the rounds fired resulted in an equal number of airbursts and impact bursts.

MIXED AIR

- a spotting or an observation reported by a spotter or an observer to indicate that the rounds fired resulted in both airbursts and impact bursts, with a majority of the bursts being airbursts.

MIXED GRAZE

- a spotting or an observation reported by a spotter or an observer to indicate that the rounds fired resulted in both airbursts and impact bursts, with a majority of the bursts being impact bursts.

muzzle velocity

- the velocity of a projectile with respect to the muzzle at the instant the projectile leaves the muzzle of the weapon.

muzzle velocity variation

- the change in muzzle velocity of a weapon from the standard muzzle velocity expressed in meters per second.

N

northing

- the northward (that is, from bottom to top) reading of grid values on a map.

number of rounds

- the number of projectiles per tube to be fired on a specified target.

⊙

observation post

- a position from which military observations are made or fire directed and adjusted and which possesses appropriate communication. It may be airborne. The point selected for the observation and correction of fire.

observer-target line

- an imaginary straight line from the observer or the spotter to the target.

observer-target range

- the distance along an imaginary straight line from the observer or the spotter to the target.

obturation

- any process that prevents the escape of gases from the tube of a weapon during the firing of a projectile.

ogive

- the curved forward part up to and including the pointed end of a projectile; also called head.

on-call targets

- planned targets, other than scheduled targets, on which fire is delivered when requested.

open sheaf

- a type of sheaf in which each gun fires at a unique time, deflection, and quadrant elevation to cause the rounds to impact in a straight line, perpendicular to the GT azimuth and centered on the target, with bursts separated by one bursting radius.

origin of the trajectory

- the center of the muzzle of a gun at the instant the projectile leaves it.

OUT

- (in conduct of fire procedures only) indicates the end of a transmission, but the same station is expected to transmit. It also indicates the termination of a read back.
- (in normal radiotelephone procedures other than conduct of fire) indicates that this is the end of the transmission, and no answer is required or expected.

OVER

- a spotting or an observation used by a spotter or an observer to indicate that a burst has occurred beyond the target in relation to the observer-target line.
- (for normal radiotelephone procedures other than conduct of fire) indicates that this is the end of the transmission, and an answer is expected.

P**point-detonating fuze**

- a fuze located in the nose of a projectile that is initiated upon impact.

polar coordinates

- the direction, distance, and vertical shift from a known point to another point; for example 6,200 mils, 300 meters, up 20 mils.
- consists of the direction, distance, and vertical correction (shift) from the observer's position to the target.

polar plot

- the method of locating a target or a point on the map by means of polar coordinates.

predicted fire

- the term used to describe the ultimate delivery technique of applying accurately computed corrections (not determined by firing) to standard firing data for all nonstandard conditions of the weather/weapon/ammunition combination and for the rotation of the earth. It implies the capability of delivering accurate surprise nonnuclear or nuclear fires on a target of known location in any direction from the weapon position and limited in range only by the characteristics of the weapon and ammunition used.

probable error

- the measurement of the impact distribution in the dispersion pattern around the mean point of impact.

projectile

- an object projected by an applied exterior force and continuing in motion by virtue of its own inertia such as a bullet, bomb, shell, or grenade. A term also applied to rockets and to guided missiles.

propellant

- that which provides the energy required for propelling a projectile. Specifically, an explosive charge for propelling a bullet, shell, or the like. Also a fuel, either solid or liquid, for propelling a rocket, missile, or the like.

propelling charge

- a powder charge that is set off in a weapon to propel a projectile from it; the propellant. Burning of the confined propellant produces gases that force the projectile out.

propellant increment

- a distinct portion of a propelling charge designed to permit separation from the total charge for range-adjustment purposes.

proximity fuze

- a fuze designed to detonate a projectile, bomb, mine, or charge when activated by an external influence in the close vicinity of a target. The variable time fuze is one type of proximity fuze.

Q

quadrant elevation

- the angle between the level base of the trajectory/horizontal and the axis of the bore when laid. It is the algebraic sum of the elevation, angle of site, and complementary angle of site.

R

range

- the distance between any given point and an object or a target.
- the extent or distance limiting the operation or action of something such as the range of an airplane, a vehicle, or a gun.
- the distance that can be covered over a hard surface by a ground vehicle, with its rated payload, using the fuel in its tanks and in cans normally carried as part of the ground vehicle equipment.
- an area equipped for practice in shooting at targets (also called target range).

range correction

- a change in firing data necessary to allow for deviation of range due to weather, ammunition, or other nonstandard conditions.

range-deflection protractor

- a device used to measure range and deflection.

range K

- a correction expressed in meters per 1,000 meters range to correct for nonstandard conditions.

range probable error

- the range error caused by dispersion that will be exceeded as often as not in an infinite number of rounds fired at the same elevation. It is one eights the length of the dispersion pattern at its greatest length. The value is given in the firing tables.

range spread

- the technique used to place the mean point of impact of two or more units 100 meters apart on the gun-target line.

REPEAT

- an order or request to fire again the same number of rounds with the same method of fire.

rotating band

- the soft metal band around a projectile near its base. The rotating band makes the projectile fit tightly in the bore by centering the projectile, thus preventing the escape of gas and giving the projectile its spin.

round

- one shot fired by a weapon.
- all of the parts that make up the ammunition necessary to fire one shot. A round consists of a primer, a propelling charge, a projectile, and a fuze. In fixed ammunition, these parts of a round are held together with a shell case. In small arms ammunition, the projectile is called a bullet, and the complete round is called a cartridge.

ROUNDS COMPLETE

- the term used to report that the number of rounds specified in fire for effect have been fired.

S

sheaf

- planned planes of fire that produce a desired pattern of bursts with rounds fired by two or more weapons.

SHELL (specify)

- a command or request indicating the type of projectile to be used.

shell

- a hollow projectile filled with explosive, chemical, or other material as opposed to shot, which is a solid projectile.
- a shotgun cartridge.
- to bombard; to fire a number of rounds at a target.

shift

- the transfer of fire from one target to another.
- to transfer fire from one target to another.

- the deflection difference from one designated point to another used in opening or closing the sheaf of artillery or mortar units.

SHORT

- a spotting or an observation reported by a spotter or an observer to indicate that a burst occurred short of the target in relation to the spotting line.

short

- a round that strikes or bursts on the near side of the target; a round fired without sufficient range to reach the target.

shot

- pellets, small balls, or slugs used in shotgun shells, canisters, and some other types of ammunition.
- a report that indicates that a gun or guns have been fired.

side spray

- fragments from a bursting shell that are thrown sideways from the line of flight.

special sheaf

- a type of sheaf in which each gun fires a unique time, deflection, and quadrant elevation to cause the rounds to impact in a specific geometrical pattern.

SPLASH

- a word transmitted by a firing ship or artillery fire direction center to the spotter 5 seconds before the estimated time of the impact of a salvo or a round.

spotting

- a process of determining, by visual or electronic observation, deviations of artillery or naval gunfire from the target in relation to a spotting line.
- the process of supplying necessary information for the adjustment or the analysis of fire.

spotting line

- the gun-target line, the observer-target line, or a reference line used by the spotter or observer in making spot corrections.

square

- in artillery, a mark or measurement on projectiles to denote standard weight or deviation from a standard weight.

supplemental charge

- a cylindrical container, usually filled with trinitrotoluene, used in deep-cavitized projectiles to fill the void between an ordinary fuze and booster combination and the bursting charge.

sustained rate of fire

- the actual rate of fire that a weapon can continue to deliver for an indefinite length of time without seriously overheating.

T

target grid

- a device for converting the observer's target locations and corrections with respect to the observer-target line to target locations and corrections with respect to the gun-target line.

time of flight

- the time, in seconds, from the instant a projectile leaves the muzzle of a weapon to the instant it strikes or bursts.

trajectory

- the path of a projectile, missile, or bomb in flight.

transfer limit

- the maximum difference in direction and range from the location of a checkpoint within which limits corrections computed for the checkpoint are assumed to be sufficiently accurate to warrant application to any target justifying its attack by a transfer of fire.

U

UP

- a term transmitted in a call for fire to indicate that the target is higher in altitude than the point that has been used as a reference point for the target location.
- a correction used by a spotter or an observer to indicate that an increase in height of burst is desired.

V

vertical angle

- the angle measured vertically, up or down, from a horizontal plane of reference. The vertical angle is expressed as plus or minus depending on whether the position is above

(plus) or below (minus) the horizontal plane.

vertical clearance

the vertical distance by which a projectile must clear an intervening crest.

vertical interval

the difference in altitude between two specified points or locations; for example,

the battery or firing ship and the target, the observation post and the target, the location of a previously fired target and a new target, the observer and a height of burst, and a battery or firing ship and a height of burst.

—the difference in height between the weapon and the desired burst point.

ACRONYMS AND ABBREVIATIONS

AC	aiming circle	CSF	complementary angle of site factor
ADAM	area denial artillery munitions	CSR	controlled supply rate
adj	adjust, adjusting, adjusted	ctg	cartridge
AF	adjust fire	dE	difference in easting
alt	altitude	df	deflection
AMC	at my command	dH	difference in height
AO	air observer	DMD	digital message device
APICM	antipersonnel improved conventional munitions	dN	difference in northing
app	apparent	DNL	do not load
ATGM	antitank guided missile	DPICM	dual-purpose improved conventional munitions
az	azimuth	DS	direct support
bal	ballistics	DTG	date-time group
BCS	battery computer system	EFC	equivalent full charge
BCU	battery computer unit	el	elevation
BMA	battery-minefield angle	EOL	end of the orienting line
bn	battalion	EOM	end of mission
btry	battery	EXEC	execute (TACFIRE and BCS)
BUCS	backup computer system	FA	field artillery
cal	caliber	FADAC	field artillery digital automatic computer
CB	center of battery	FASCAM	family of scatterable mines
CEOI	communications-electronics operation instructions	FCI	fire control information
CF	command fire	FCO	fire control officer
CFF	call for fire	FDC	fire direction center
chg	charge	FDO	fire direction officer
comp site	complementary angle of site	FFE	fire for effect
corr	correction		

FIST	fire support team	JMEM	joint munitions effectiveness manual
FLOT	forward line of own troops	JMEM/SS	joint munitions effectiveness manual for surface-to-surface weapons
FO	forward observer		
FPF	final protective fires		
FS	fuze setting		
FSE	fire support element	LA	low angle
FSO	fire support officer		
FT	firing table	m	meter
FTX	field training exercise	m/	mil
fz	fuze	MAP MOD	map modification
		max	maximum
GB	green bag	MDP	meteorological datum plane
GBC	geographical battery center	met	meteorological, meteorology
GDU	gun display unit	MHL	manufacturer's hairline
GFT	graphical firing table	MIJI	meaconing, intrusion, jamming, interference
GMET	graphical munitions effectiveness table	min	minute
GQ	gunner's quadrant	MPI	mean point of impact
GSR	general support reinforcing	m/s	meters per second
GST	graphical site table	MSU	mutual support unit
GTAZ	gun-target azimuth	MT	mechanical time
GTRG	gun-target range	MTO	message to observer
G/VLLD	ground/vehicular laser locator designator	MTSQ	mechanical time super quick
		MV	muzzle velocity
		MVV	muzzle velocity variation
HA	high angle		
HB	high burst, height of burst	NBC	nuclear, biological, chemical
HC	hydrochloroethane	NCS	net control station
HCO	horizontal control operator		
HE	high explosive	OL	orienting line
HEP	high explosive plastic	OB	operator-burst
HES	high explosive spotting	OP	observation post
HET	high explosive tracer	OPCODE	operations code
HHC	hand-held calculator	OS	orienting station
HOB	height of burst	OT	observer-target
		OT VI	observer-target vertical interval
IAW	in accordance with		
ICAO	International Civil Aviation Organization	PADS	position and azimuth determining system
ICM	improved conventional munition	PD	point detonating
illum	illumination		
ir	infrared		

PED	deflection probable error	SCA	section chief assembly
PE_{HB}	height-of-burst probable error	SD	self-destruct
PE_R	range probable error	sec	seconds
PE_{RB}	range-to-burst probable error	si	site
% CAS	percentage of casualties (on GMET)	smk	smoke
PE_{TB}	time-to-burst probable error	STANAG	standardization agreement
PE_V	vertical probable error	STX	situational training exercise
PMCS	preventive maintenance checks and services	TACFIRE	tactical fire direction system
plt	platoon	TAG	target above gun
PMOD	powder model	TBG	target below gun
PRF	pulse repetition frequency	TF	time of flight
proj	projectile	TFC	total fuze correction
prox	proximity	TFT	tabular firing table
PTF	piece to fire	tgt	target
		ti	time
Q	quick	TLE	target location error
QE	quadrant elevation	TOE	tables of organization and equipment
QSTAG	quadripartite standardization agreement	TOT	time on target
		tot	total
RAAMS	remote antiarmor mine system	UTM	universal transverse mercator
RAP	rocket-assisted projectile	VA	vertical angle
RATELO	radiotelephone operator	VCO	vertical control operator
rd	round	VFMED	variable format message entry device
RDP	range-deflection protractor	VI	vertical interval
		VT	variable time
reg pt	registration point	WP	white phosphorus
rep	replot	wpn	weapon
rg	range	WR	when ready
RPV	remotely piloted vehicle		
RT	radii of target, radius of target	yd	yard

REFERENCES

PUBLICATION INDEXES

Department of the Army pamphlets of the 310-series should be consulted frequently for the latest changes or revisions to references in this appendix and for new publications relating to material covered in this publication.

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310-25	Dictionary of United States Army Terms
310-50	Catalog of Abbreviations and Brevity Codes
385-63	Policies and Procedures for Firing Ammunition for Training, Target Practice, and Combat

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310-1	Consolidated Index of Army Publications and Blank Forms
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6-13E1/2/3	Soldier's Manual: 13E, Cannon Fire Direction Specialist (Skill Levels 1/2/3)
6-15	Field Artillery Meteorology
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6-20-2 (HTF)	Division Artillery, Field Artillery Brigade, and Field Artillery Section (Corps)
6-30	The Field Artillery Observer
6-40-3	Operation of the Gun Direction Computer M18, Cannon Gunnery Application
6-50	Field Artillery Cannon Battery
6-121	Field Artillery Target Acquisition
6-122	Field Artillery Sound Ranging
6-141-1	Field Artillery Target Analysis and Weapons Employment: Nonnuclear
6-141-2	(C) Field Artillery Target Analysis and Weapons Employment: Nonnuclear (U)
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11-5820-477-12	Operator's and Organizational Maintenance Manual: Radio Set Control Groups AN/GRA-39, AN/GRA-39A and AN/GRA-39B
11-5830-340-12	Operator's and Organizational Maintenance Manual (Including Repair Parts and Special Tools Lists): Intercommunication Set, AN/VIC-1(V) Controls, Intercommunications Set, C-10456/VRC, C-10680/VRC and Amplifier, Audio Frequency, AM-7046/VRC
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11-5985-357-13	Operator's, Organizational, and Direct Support Maintenance Manual for Antenna Group, OE-254/GRC
11-7440-283-12-1	Operator's and Organizational Maintenance Manual for Computer Group, Gun Direction, OL-200/GYK-29(V)
38-750	The Army Maintenance Management System (TAMMS)
43-0001-28	Army Ammunition Data Sheets for Artillery Ammunition: Guns, Howitzers, Mortars, Recoilless Rifles, Grenade Launchers, and Artillery Fuzes (Federal Supply Class 1310, 1315, 1320, 1390)

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4505	155-mm Nuclear Computation—Met Correction Technique
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4982-1-R	M90 Velocimeter Work Sheet
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FIRING TABLES (FT)

8-Q-1	Cannon, 8-Inch Howitzer, M201 on Howitzer, Heavy, Self-Propelled: 8-Inch, M110A1 and Cannon, 8-Inch Howitzer,
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	M201A1 on Howitzer, Heavy, Self-Propelled: 8-Inch M110A2 and Firing Projectile, HE, M106
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155-ADD-J-1	Addendum to FT 155-AN-1 for Projectile, HE, M483A1
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155-AN-1	Cannon, 155-mm Howitzer, M185 on Howitzer, Medium, Self-Propelled, 155-mm, M109A1 and Howitzer, Medium, Self-Propelled, 155-mm, M109A1B Firing Projectile, HE, M483A1

Note. Because of the rapidly changing status of firing tables, the Gunnery Department, USAFAS, publishes annually a list of current firing table information. The publication is Gunnery R&A Division Reference Note 1. Users may request a copy and be placed on the mailing list by writing:

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STANAG 4119	Adoption of a Standard (Cannon) Artillery Firing Table Format
QSTAG 220	Cannon Artillery Equipment and Procedures for the Manual Determination of Firing Data for Nonstandard Conditions for Post 1970
QSTAG 224	Manual Fire Direction Equipment, Target Classification and Methods of Engagement for Post 1970
QSTAG 225	Call for Fire Formats
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USAHSC (HSOP-ST)
USAJFKSWCS (AOJK-DTD-M)

Commandant,
USAADASCH (ATSA-DT)
USAARMS (ATSB-AC)
(CONT)

CONSOLIDATED LIST OF ADTL THAT MAY HAVE THE
RESTRICTIVE DISTRIBUTION STATEMENT REMOVED
(UPDATED SEP 94)

FM 24-22	FM 54-30
FM 24-24	FM 54-40
FM 24-27	FM 54-50
FM 24-30	FM 55-1
FM 24-40	FM 55-9
FM 25-4	FM 55-10
FM 25-5	FM 55-15
FM 25-100	FM 55-20
FM 25-101	FM 55-21
FM 26-2	FM 55-50

CONSOLIDATED LIST OF ADTL THAT MAY HAVE THE
RESTRICTIVE DISTRIBUTION STATEMENT REMOVED
(UPDATED SEP 94)

FM 1-100	FM 6-20	FM 11-53	FM 24-22	FM 54-30
FM 1-101	FM 6-20-1	FM 11-54	FM 24-24	FM 54-40
FM 1-102	FM 6-20-2	FM 11-55	FM 24-27	FM 54-50
FM 1-103	FM 6-20-10	FM 11-58	FM 24-30	FM 55-1
FM 1-104	FM 6-20-30	FM 11-59	FM 24-40	FM 55-9
FM 1-107	FM 6-20-40	FM 11-70	FM 25-4	FM 55-10
FM 1-108	FM 6-20-50	FM 11-75	FM 25-5	FM 55-15
FM 1-109	FM 6-30	FM 11-76	FM 25-100	FM 55-20
FM 1-111	FM 6-40	FM 11-82	FM 25-101	FM 55-21
FM 1-112	FM 6-40A	FM 12-6	FM 26-2	FM 55-50
FM 1-113	FM 6-50	FM 12-50	FM 31-19	FM 55-60
FM 1-114	FM 6-60	FM 14-6	FM 31-24	FM 55-65
FM 1-116	FM 6-121	FM 14-7	FM 31-25	FM 55-501
FM 1-117	FM 6-141-1	FM 16-1	FM 31-27	FM 55-501-2
FM 1-118	FM 6-300	FM 19-1	FM 31-82	FM 55-509
FM 1-120	FM 7-7	FM 19-4	FM 34-10-1	FM 55-509-1
FM 1-140	FM 8-27	FM 19-10	FM 34-13	FM 55-509-3
FM 1-202	FM 8-34	FM 19-15	FM 34-35	FM 55-511
FM 1-203	FM 9-6	FM 19-20	FM 34-37	FM 63-1
FM 1-220	FM 9-13	FM 19-25	FM 34-40-2	FM 63-2
FM 1-230	FM 9-35	FM 19-30	FM 34-40-7	FM 63-2-1
FM 1-240	FM 9-38	FM 19-35	FM 34-80	FM 63-3
FM 1-300	FM 9-43-1	FM 19-40	FM 34-82	FM 63-4
FM 1-302	FM 9-43-2	FM 19-60	FM 34-85	FM 63-20
FM 1-400	FM 9-43-3	FM 20-22	FM 38-85-1	FM 63-21
FM 1-402	FM 9-59	FM 21-16	FM 38-746	FM 63-23
FM 1-500	FM 9-207	FM 21-17	FM 43-12	FM 63-24
FM 1-506	FM 10-18	FM 21-75	FM 43-20	FM 71-2
FM 1-508	FM 10-27	FM 21-76	FM 44-1	FM 71-100
FM 1-511	FM 10-52	FM 21-305	FM 44-3	FM 71-100-1
FM 1-513	FM 10-52-1	FM 21-306	FM 44-4	FM 100-2-1
FM 5-36	FM 10-67	FM 22-9	FM 44-5	FM 100-2-2
FM 5-100	FM 10-69	FM 22-101	FM 44-8	FM 100-15
FM 5-101	FM 10-70	FM 22-103	FM 44-11-2	FM 100-15-1
FM 5-103	FM 10-70-1	FM 23-24	FM 44-15	FM 100-22
FM 5-116	FM 10-200	FM 23-27	FM 44-15-1	FM 100-37
FM 5-134	FM 10-427	FM 23-35	FM 44-16	FM 101-5
FM 5-233	FM 11-29	FM 23-67	FM 44-18	FM 101-5-1
FM 5-335	FM 11-30	FM 23-91	FM 44-18-1	FM 700-80
FM 5-551	FM 11-37	FM 24-1	FM 44-30	FM 701-58
FM 6-2	FM 11-38	FM 24-2	FM 44-31	
FM 6-15	FM 11-41	FM 24-10	FM 44-63	
FM 6-16	FM 11-43	FM 24-11	FM 44-90	
FM 6-16-1	FM 11-44	FM 24-12	FM 44-100	
FM 6-16-2	FM 11-45	FM 24-18	FM 46-1	
FM 6-16-3	FM 11-51	FM 24-19	FM 54-23	